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THE  
NAVAL ARCHITECT'S & SHIPBUILDER'S  
POCKET-BOOK

—  
CLEMENT MACKROW, A.I.N.A.



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THE  
NAVAL ARCHITECT'S AND SHIPBUILDER'S  
POCKET-BOOK

OF  
**Formulae, Rules, and Tables**  
AND

MARINE ENGINEER'S AND SURVEYOR'S  
HANDY BOOK OF REFERENCE

BY  
CLEMENT MACKROW

NAVAL DRAUGHTSMAN

ASSOCIATE OF THE INSTITUTION OF NAVAL ARCHITECTS



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1879

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retical training, and to whom such a book as this would be but of small service were they not first enabled to gather a few elementary principles, by which means they may learn to use and understand these Formulæ.

In justice to those authors whose works have been consulted, it must be added that most of the Rules and Formulæ here given are not original, although perhaps appearing in a new shape with a view to making them simpler.

There are many into whose hands this work will fall who are well able to criticise it, both as to the usefulness and the accuracy of the matter it contains. From such critics the Author invites any corrections or fresh material which may be useful for future editions.

CLEMENT MACKROW.

LONDON, *July* 1879.

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# MACKROW'S

# POCKET BOOK

OF

## FORMULÆ, RULES, AND TABLES

FOR

## NAVAL ARCHITECTS AND SHIP-BUILDERS.

---

### SIGNS AND SYMBOLS.

THE following are some of the signs and symbols commonly used in algebraical expressions:—

**=** This is the sign of equality. It denotes that the quantities so connected are equal to one another; thus, 3 feet = 1 yard.

**+** This is the sign of addition, and signifies plus or more; thus,  $4 + 3 = 7$ .

**—** This is the sign of subtraction, and signifies minus or less; thus,  $4 - 3 = 1$ .

**×** This is the sign of multiplication, and signifies multiplied by or into; thus,  $4 \times 3 = 12$ .

**÷** This is the sign of division, and signifies divided by; thus,  $4 \div 2 = 2$ .

**() {} []** These signs are called brackets, and denote that the quantities between them are to be treated as one quantity; thus,  $5\{3(4 + 2) - 6(3 - 2)\} = 5(18 - 6) = 60$ .

**—** This sign is called the bar or vinculum, and is sometimes used instead of the brackets; thus,  $3(4 + 2) - 6(3 - 2) \times 5 = 60$ .

Letters are often used to shorten or simplify a formula. Thus, supposing we wish to express length  $\times$  breadth  $\times$  depth, we might put the initial letters only, thus,  $l \times b \times d$ , or, as is usual when algebraical symbols are employed, leave out the sign  $\times$  between the factors and write the formula *l.b.d.*

When it is wished to express division in a simple form the divisor is written under the dividend; thus,  $(x + y) \div z = \frac{x + y}{z}$ .

$:$ ,  $::$ ,  $\therefore$ , These are signs of proportion; the sign  $=$  is to, the sign  $:: =$  as; thus,  $1 : 3 :: 3 : 9$ , 1 is to 3 as 3 is to 9.

$<$  This sign denotes less than; thus  $2 < 4$  signifies 2 is less than 4.

$>$  This sign denotes more than; thus  $4 > 2$  signifies 4 is more than 2.

$\therefore$  This sign signifies because.

$\therefore$  This sign signifies therefore. *Ex.*:  $\therefore$  9 is the square of 3  $\therefore$  3 is the root of 9.

$\sim$  This sign denotes difference, and is placed between two quantities when it is not known which is the greater; thus  $(x \sim y)$  signifies the difference between  $x$  and  $y$ .

$^{\circ}$ ,  $'$ ,  $''$  These signs are used to express certain angles in degrees, minutes, and seconds; thus 25 degrees 4 minutes 21 seconds would be expressed  $25^{\circ} 4' 21''$ .

*Note.*—The two latter signs are often used to express feet and inches; thus 2 feet 6 inches may be written  $2' 6''$ .

$\sqrt{\phantom{x}}$  This sign is called the radical sign, and placed before a quantity indicates that some root of it is to be taken, and a small figure placed over the sign, called the exponent of the root, shows what root is to be extracted.

Thus  $\sqrt{a}$  or  $\sqrt{a}$  means the square root of  $a$ .

$\sqrt[3]{a}$	„	cube	„
$\sqrt[4]{a}$	„	fourth	„

$\frac{\sqrt{a}}{b}$  This denotes that the square root of  $a$  has to be taken and divided by  $b$ .

$\frac{b}{\sqrt{a}}$  This denotes that  $b$  has to be divided by the square root of  $a$ .

$\sqrt{\frac{a+b}{a+d}}$  This denotes that the square root of  $a+b$  has to be divided by the square root of  $a+d$ . It may also be written thus,  $\sqrt{\frac{a+b}{a+d}}$ , or  $\frac{\sqrt{a+b}}{\sqrt{a+d}}$ .

$\propto$  This is another sign of proportion. *Ex.*:  $a \propto b$ ; that is,  $a$  varies as or is proportional to  $b$ .

$\infty$  This sign expresses infinity; that is, it denotes a quantity greater than any finite quantity.

$0$  This sign denotes a quantity infinitely small, nought.

$\angle$  This sign denotes an angle. *Ex.*:  $\angle ab$  would be written, the angle  $ab$ .



$\perp$  This sign denotes a right angle.

$\perp$  This sign denotes a perpendicular; as,  $ab \perp cd$ , i.e.  $ab$  is perpendicular to  $cd$ .

$\Delta$  This sign signifies a triangle; thus,  $\Delta abc$ , i.e. the triangle  $abc$ .

$\parallel$  This sign signifies parallel to. *Ex.*:  $ab \parallel cd$  would be written,  $ab$  is parallel to  $cd$ .

$f$  or  $F$  These express a function; as,  $a = fx$ ; that is,  $a$  is a function of  $x$  or equals  $x$ .

$\int$  This is the sign of integration; that is, it indicates that the expression before which it is placed is to be integrated. When the expression has to be integrated twice or three times the sign is repeated (thus,  $\iint$ ,  $\iiint$ ); but if more than three times an index is placed above it (thus,  $\int^n$ ).

$D$  or  $d$  These are the signs of differentiation; an index placed above the sign (thus,  $d^2$ ) indicates the result of the repetition of the process denoted by that sign.

$\Sigma$  This sign (the Greek letter sigma) is used to denote that the algebraical sum of a quantity is to be taken. It is commonly used to indicate the sum of finite differences, in nearly the same manner as the symbol  $f$ .

$\bigcirc$  This sign is sometimes used instead of  $\pi$ , being a modification of the letter  $C$ , for circumference.

$\square$  This sign is sometimes used instead of  $e$ , being a modification of the letter  $B$ , for base.

$g$  This sign is used to denote the force of gravity at any given latitude.

$\pi$  The Greek letter pi is invariably used to denote 3.14159; that is, the ratio borne by the diameter of a circle to its circumference.

As the letters of the Greek alphabet are of constant recurrence in mathematical formulæ it has been deemed advisable to append the following table:—

A $\alpha$ Alpha.	I $\iota$ Iota.	P $\rho$ Rho.
B $\beta$ Beta.	K $\kappa$ Kappa.	$\Sigma$ $\sigma$ Sigma.
$\Gamma$ $\gamma$ Gamma.	$\Lambda$ $\lambda$ Lambda.	T $\tau$ Tau.
$\Delta$ $\delta$ Delta.	M $\mu$ Mu.	$\Upsilon$ $\upsilon$ Upsilon.
E $\epsilon$ Epsilon.	N $\nu$ Nu.	$\Phi$ $\phi$ Phi.
Z $\zeta$ Zeta.	$\Xi$ $\xi$ Xi.	$\chi$ $\chi$ Chi.
H $\eta$ Eta.	O $\omicron$ Omicron.	$\Psi$ $\psi$ Psi.
$\Theta$ $\theta$ Theta.	$\Pi$ $\pi$ Pi.	$\Omega$ $\omega$ Omega.

## DECIMAL FRACTIONS.

*Decimal Fractions* are those which have 10, 100, 1000, &c., for a denominator, and are expressed by writing the numerator only and placing a point before it on the left hand.

$$\text{Ex. 1. } \frac{1}{10} = \cdot 1. \quad \frac{76}{100} = \cdot 76. \quad \frac{876}{1000} = \cdot 876.$$

$$\text{Ex. 2. } \frac{3}{10} = \cdot 3. \quad \frac{3}{100} = \cdot 03. \quad \frac{3}{1000} = \cdot 003.$$

$$\text{Ex. 3. } 113 \cdot 3 = 113 \frac{3}{10} = \frac{1133}{10} = \frac{11330}{100}.$$

$$\text{Ex. 4. } 113 \cdot 03 = \frac{11303}{100} = \frac{11303}{100} = \frac{11303}{100}.$$

## ADDITION OF DECIMALS.

**RULE.**—Arrange the numbers so that all the decimal points come directly under one another; add them together as in whole numbers, and point off as many figures for decimals as are equal to the greatest number of decimals in any of the given numbers.

*Ex.:* Add together 3·79, ·117, 87·225, 478·91.

$$\begin{array}{r} 3\cdot79 \\ \cdot117 \\ 87\cdot225 \\ 478\cdot91 \\ \hline 570\cdot042. \text{ Ans.} \end{array}$$

## SUBTRACTION OF DECIMALS.

**RULE.**—Place the numbers under one another, as in addition; subtract as in whole numbers, keeping the decimal point in the remainder directly under those above it.

$$\begin{array}{r} \text{Ex.}: \text{From } 97\cdot378 \\ \text{take } 46\cdot4972 \\ \hline 50\cdot8608. \text{ Ans.} \end{array}$$

## MULTIPLICATION OF DECIMALS.

**RULE.**—Multiply the factors together, as in whole numbers; then point off from the product as many decimal places as there are in both factors, supplying any deficiency by annexing ciphers to the left hand.

$$\begin{array}{r} \text{Ex. 1. Mult. } 4\cdot735 \\ \text{by } \cdot374 \\ \hline 18940 \\ 33145 \\ 14205 \\ \hline 1\cdot770890. \text{ Ans.} \end{array}$$

$$\begin{array}{r} \text{Ex. 2. Mult. } \cdot04735 \\ \text{by } \cdot0374 \\ \hline 18940 \\ 33145 \\ 14205 \\ \hline \cdot001770890. \text{ Ans.} \end{array}$$

## DIVISION OF DECIMALS.

**RULE.**—Remove the decimal point in the dividend as many places to the right as there are decimal places in the divisor; supply any deficiency by annexing ciphers. Then make the divisor a whole number, and proceed as in the division of simple numbers, and the quotient will contain as many decimal places as are *used* in the dividend.

*Ex. 1.* Divide 74·23973 by 6·12. *Ex. 2.* Divide ·7423973 by 612.

612) 7423·973 (12·130. *Ans.*

$$\begin{array}{r}
 612 \\
 \underline{1303} \\
 1224 \\
 \underline{799} \\
 612 \\
 \underline{1877} \\
 1836 \\
 \underline{413}
 \end{array}$$

612) ·7423973 (·0012130. *Ans.*

$$\begin{array}{r}
 612 \\
 \underline{1303} \\
 1224 \\
 \underline{799} \\
 612 \\
 \underline{1877} \\
 1836 \\
 \underline{413}
 \end{array}$$

## TO REDUCE ANY FRACTION TO A DECIMAL.

**RULE.**—Annex ciphers to the numerator till it be equal to or greater than the denominator; divide by the denominator, as in division of decimals, and the quotient will be the decimal required.

*Ex. 1.* Reduce  $\frac{7}{256}$  to a decimal.

256) 7·00000000 (·02734375. *Ans.*

$$\begin{array}{r}
 512 \\
 \underline{1880} \\
 1792 \\
 \underline{880} \\
 768 \\
 \underline{1120} \\
 1024 \\
 \underline{960} \\
 768 \\
 \underline{1920} \\
 1792 \\
 \underline{1280} \\
 1280
 \end{array}$$

*Ex. 2.* Reduce  $\frac{7}{12}$  to a decimal.

12) 7·00000000  
·58333333. *Ans.*

## TO REDUCE NUMBERS OF DIFFERENT DENOMINATIONS INTO DECIMALS.

**RULE 1.**—Reduce the given weight or measure, &c., into the lowest denomination given, for a dividend; then reduce the

integer into the same denomination for a divisor; the resulting fraction, changed to a decimal, will be the decimal required.

**RULE 2.**—Divide the least denomination by such a number as will reduce it to the next greater; to the decimal so obtained prefix the given number of the same denomination; then divide by such a number as will reduce it to the next greater; thus proceed till it be reduced to the decimal of the required integer.

*Ex. 1* to **RULE 1.**—Reduce 2 cwt. 3 qrs. 21 lbs. to the decimal of a ton.

$$\frac{2 \text{ cwt. } 3 \text{ qrs. } 21 \text{ lbs.}}{1 \text{ ton}} = \frac{329 \text{ lbs.}}{2240 \text{ lbs.}} = .146875 \text{ ton};$$

or, by **RULE 2**—

$$\begin{array}{r} 28 \left\{ \begin{array}{l} 7) \ 21 \cdot 0 \text{ lbs.} \\ 4) \ 3 \cdot 0 \\ 4) \ 3 \cdot 75 \text{ qrs.} \\ 20) \ 2 \cdot 9375 \text{ cwts.} \end{array} \right. \\ \text{Ans. } .146875 \text{ ton.} \end{array}$$

*Ex. 2* to **RULE 1.**—Reduce 2 ft. 9 in. to the decimal of a yard.

$$\frac{2 \text{ ft. } 9 \text{ in.}}{1 \text{ yard}} = \frac{33 \text{ in.}}{36 \text{ in.}} = .916666 \text{ yard};$$

or, by **RULE 2**—

$$\begin{array}{r} 12) \ 9 \text{ in.} \\ 3) \ 2 \cdot 75 \text{ feet} \\ \text{Ans. } .91666 \text{ yard.} \end{array}$$

### TO FIND THE VALUE OF ANY DECIMAL.

**RULE.**—Multiply the given decimal by the number of parts contained in the next lesser denomination, and point off from the product as many figures as the decimal consists of. Multiply the remaining decimal by the number of parts in the next lesser denomination, and point off as many decimals in the product as before. Proceed thus till you have brought out the least known parts of the integer.

*Ex. 1.* What is the value of .146875 of a ton? *Ex. 2.* What is the value of .91666 of a yard?

$$\begin{array}{r} .146875 \\ \quad 20 \\ \hline \text{cwts. } 3 \cdot 937500 \\ \quad 4 \\ \hline \text{qrs. } 3 \cdot 750000 \\ \quad 28 \\ \hline \text{lbs. } 21 \cdot 000000 \end{array}$$

*Ans.* = 3 cwts. 3 qrs. 21 lbs.

$$\begin{array}{r} .91666 \\ \quad 3 \\ \hline \text{feet } 2 \cdot 74998 \\ \quad 12 \\ \hline \text{in. } 8 \cdot 99999 \\ \text{Ans.} = 2 \text{ ft. } 9 \text{ in.} \end{array}$$

PRACTICAL GEOMETRY.

1. *From any given point in a straight line to erect a perpendicular.* (Fig. 1.)

On each side of the point A in the line from which the perpendicular is to be erected set off equal distances Ab, Ac; and from b and c as centres, with any radius greater than Ab or Ac, describe arcs cutting each other at d, d'; a line drawn through dd' will pass through the point A, and Ad will be perpendicular to bc.

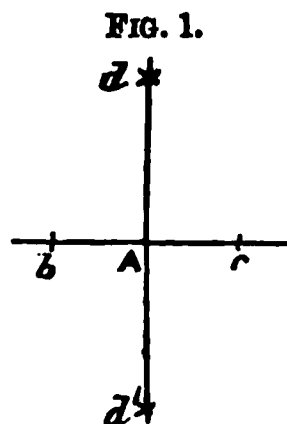


FIG. 2.

2. *To erect a perpendicular at or near the end of a line.* (Fig. 2.)

With any convenient radius, and at any distance from the given line AB, describe an arc, as BAC, cutting the given point in A; through the centre of the circle N draw the line BNC: a line drawn from the point A, cutting the intersection at C, will be the required perpendicular.

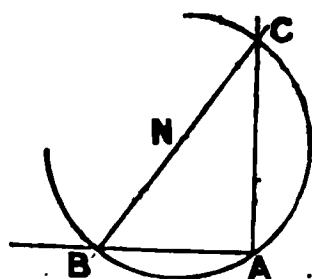
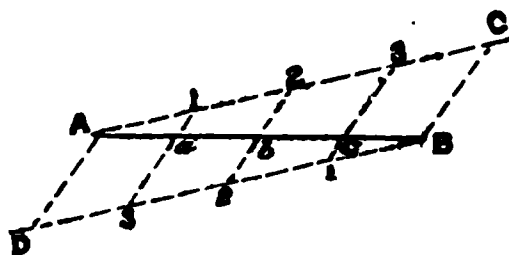


FIG. 3.

3. *To divide a line into any number of equal parts.* (Fig. 3.)

Let AB be the given straight line to be divided into a number of equal parts; through the points A and B draw two parallel lines AC and DB, forming any convenient angle with AB; upon AC and DB set off the number of equal parts required, as A-1, 1-2, &c., B-1, 1-2, &c;

join A and D, 1 and 3, 2 and 2, 3 and 1, C and B, cutting AB in a, b, and c, which will thus be divided into four equal parts.



4. *To find the length of any given arc of a circle.* (Fig. 4.)

With the radius Ac, equal to one-fourth of the length of the chord of the arc AB, and from A as a centre, cut the arc in c; also from B as a centre with the same radius cut the chord in b; draw the line cb, and twice the length of the line cb is the length of the arc nearly.

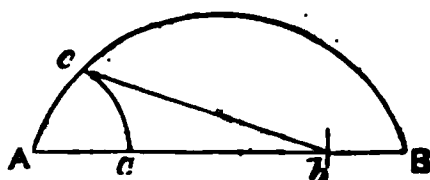
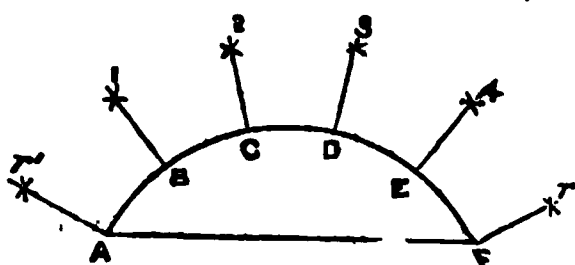


FIG. 5.

5. *To draw from or to the circumference of a circle lines tending towards the centre, when the centre is inaccessible.* (Fig. 5.)

Divide the given portion of the circumference into the desired number of parts; then with any radius less than the distance of two parts, describe arcs cutting each other as A1, O1, &c.;

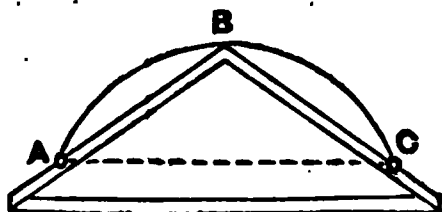




draw the lines  $B1, C2, &c.$ , which will lead to the centre, as required. To draw the end lines  $Ar, Fr'$  from  $B$  and  $E$ , with the same radii as before describe the arcs  $r, r'$ , and with the radius  $B1$ , from  $A$  as centre, cut the former arcs at  $r, r'$ ; lines then drawn from  $Ar'$  and  $Fr$  will tend towards the centre, as required.

6. To describe an arc of a circle of large radius. (Fig. 6.)

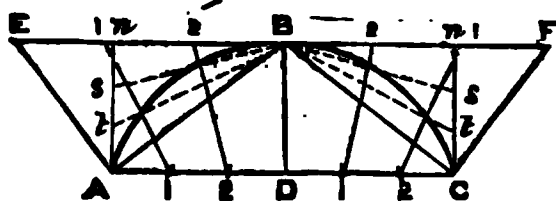
FIG. 6.



Let  $A, B, C$  be the three points through which the arc is to be drawn; join  $BA$  and  $BC$ ; then construct a flat triangular mould, having two of its edges perfectly straight and making with each other an angle equal to  $\angle ABC$ . Each of the edges should be a little longer than the chord  $AC$ . In the points  $A, C$  fix pins; and fix a pencil to the mould at  $B$ , and move the mould so as to keep its edges touching the pins at  $A$  and  $C$ , when the pencil will describe the required arc.

7. Another method. (Fig. 7.)

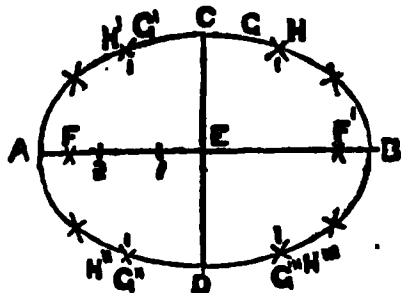
FIG. 7.



Draw the chord  $ADC$ , and draw  $EBF$  parallel to it; bisect the chord in  $D$  and draw  $DB$  perpendicular to  $AC$ ; join  $AB$  and  $BC$ ; draw  $AE$  perpendicular to  $AB$  and  $CF$  perpendicular to  $BC$ ; also draw  $An$  and  $Cn'$  perpendicular to  $AC$ ; divide  $AC$  and  $EF$  into the same number of equal parts, and  $An, Cn'$  into half that number of equal parts; join  $1$  and  $1, 2$  and  $2$ , also  $B$  and  $s, s$ , and  $B$ , and  $t, t$ ; through the points where they intersect describe a curve, which will be the arc required.

8. To describe an ellipse, the transverse and conjugate diameters being given. (Fig. 8.)

FIG. 8.



Let  $AB$  be the transverse and  $CD$  the conjugate diameters, bisecting each other at right angles in the centre  $E$ ; from  $C$  as a centre, with  $EA$  as radius, describe arcs cutting  $AB$  in  $F$  and  $F'$ , which will be the foci of the ellipse; between  $E$  and  $F$  set off any number of points, as  $1, 2$  (it is advisable that these points should be closer as they approach  $F$ ).

From  $F$  and  $F'$ , with radius  $B1$ , describe the arcs  $G, G', G'', G'''$ .

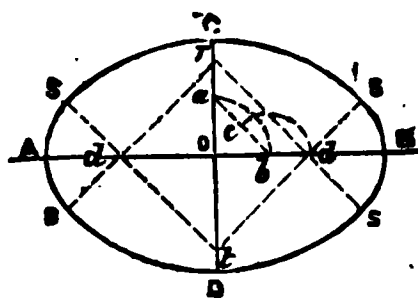
From  $F$  and  $F'$ , with radius  $A1$ , describe the arcs  $H, H', H'', H'''$ , intersecting the arcs  $G, G', G'', G'''$  in the points  $I, I, I, I$ , which will be four points in the curve.

Then strike arcs from  $F, F'$  first with  $A2$ , then with  $B2$ ; these radii intersecting will give four more points. Proceed in this way with all the points between  $A$  and  $B$ ; the curve of the ellipse must then be traced through these points by hand.

9. *Another method.* (Fig. 9.)

At  $o$ , the intersection of the two diameters, as a centre, with a radius equal to the difference of the semi-diameters, describe the arc  $ab$ , and from  $b$  as a centre with half the chord  $bca$  describe the arc  $cd$ ; from  $o$  as centre with the distance  $od$  cut the diameters in  $dr$ ,  $dt$ ; draw the lines  $rs$ ,  $rs$ ,  $ts$ ,  $ts$ ; then from  $r$  and  $t$  describe the arcs  $SDS$ ,  $SCS$ ; also from  $d$  and  $d$  describe the smaller arcs  $SAS$ ,  $SBS$ , which will complete the ellipse required.

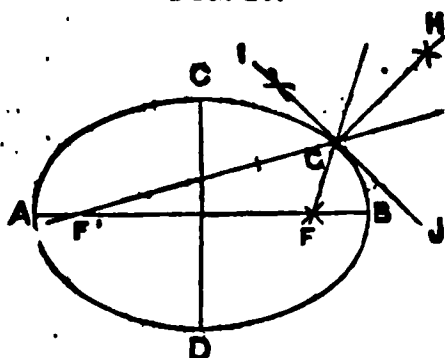
FIG. 9.



10. *To draw a tangent and a perpendicular to an ellipse at any point.* (Fig. 10.)

Let  $G$  be the point; from  $F$ ,  $F'$ , the two foci of the ellipse, draw straight lines through  $G$  and produce them; bisect the angle made by the produced parts, by  $GH$ , then  $GH$  is perpendicular to the curve; at  $G$  bisect the angle formed by  $FG$  and  $F'G$  produced, by  $IJ$ , then  $IJ$  will be the tangent to the curve at  $G$ , and it will also be perpendicular to  $GH$ .

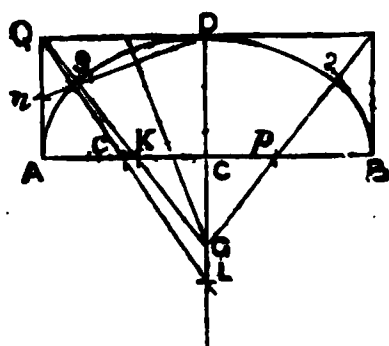
FIG. 10.



11. *To describe an elliptic arc, the span and height being given.* (Fig. 11.)

Bisect with a line at right angles the chord or span  $AB$ ; erect the perpendicular  $AQ$ , and draw the line  $QD$  equal and parallel to  $AC$ ; bisect  $AC$  in  $o$ , and  $AQ$  in  $n$ ; make  $CL$  equal to  $CD$ , and draw the line  $LcQ$ ; draw also the line  $nSD$ , and bisect  $SD$  with a line  $KG$  at right angles to it, and meeting the line  $LD$  in  $G$ ; draw the line  $GKQ$ , and make  $Cp$  equal to  $CK$ , and draw the line  $Gp2$ ; then from  $G$  as centre with the radius  $GD$  describe the arc  $SD2$ , and from  $K$  and  $p$  as centres with the radius  $AK$  describe the arcs  $AS$  and  $2B$ , which complete the arc, as required.

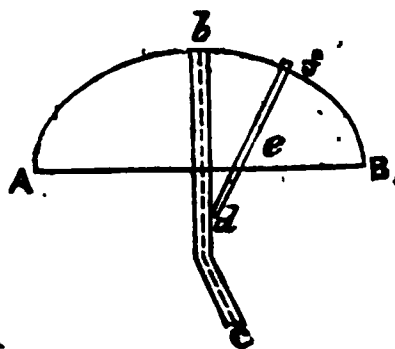
FIG. 11.



12. *Another method.* (Fig. 12.)

Bisect the chord  $AB$ , and fix at right angles to it a straight guide, as  $bc$ ; prepare of any material a rod or staff equal to half the length of the chord, as  $def$ ; at a distance from the end of the staff, equal to the height of the arc, fix a pin  $e$ , and at the extremity a tracer  $f$ ; move the staff, keeping its end to the guide and the fixed

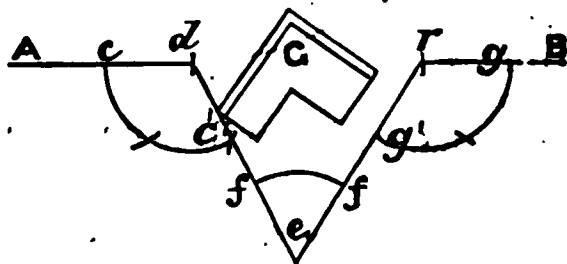
FIG. 12.



pin to the chord, and the tracer will describe a half of the arc required.

13. *To obtain by measurement the length of any direct line, though intercepted by some material object. (Fig. 13.)*

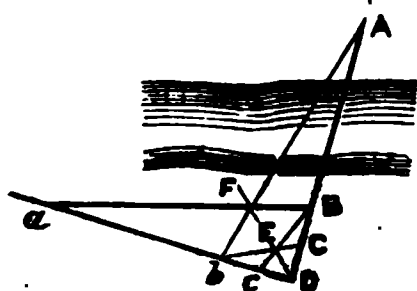
FIG. 13.



Suppose the distance between A and B is required, but the straight line is intercepted by the object G. On the point  $d$  with any convenient radius describe the arc  $cc'$ , and make the arc twice the radius  $dc$  in length; through  $c'$  draw the line  $dc'e$ , and on  $e$  describe another arc  $ff$  equal in length to the radius  $dc$ ; draw the line  $efr$  equal to  $efd$ ; from  $r$  describe the arc  $g'g$ , equal in length to twice the radius  $rg$ ; continue the line through  $rg$  to B: then A and B will make a right line, and  $de$  or  $er$  will equal the distance between  $dr$ , by which the distance between AB is obtained, as required.

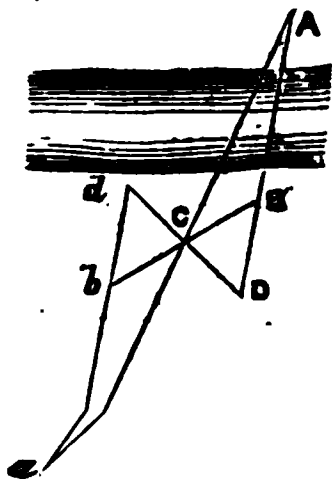
14. *To ascertain the distance geometrically of an inaccessible object on a level plane. (Fig. 14.)*

FIG. 14.



Let it be required to find the distance between A and B, A being inaccessible. Produce AB to any point D, and bisect BD in C; through D draw  $Da$ , making any angle with DA, and take DC and DB respectively and set them off on  $Da$  as  $Dc$  and  $Db$ ; join  $Bc$ ,  $Cb$ , and  $Ab$ ; through E, the intersection of  $Bc$  and  $Cb$ , draw  $DEF$  meeting  $Ab$  in F; join BF and produce it till it meets  $Da$  in  $a$ : then  $ab$  will be equal to AB, the distance required.

FIG. 15.



15. *Another method. (Fig. 15.)*

Produce AB to any point D; draw the line  $Dd$  at any angle to the line AB; bisect the line  $Dd$  in  $c$ , through which draw the line  $Bb$ , and make  $Cb$  equal to  $BC$ ; join AC and  $db$ , and produce them till they meet at  $a$ : then  $ba$  will equal BA, the distance required.

16. *To measure the distance between two objects, both being inaccessible.* (Fig. 16.)

Let it be required to find the distance between the points A and B, both being inaccessible. From any point C draw any line  $Cc$ , and bisect it in D; produce  $Ac$  and  $Bc$ , and prolong them to E and F; take the point E in the prolongation of  $Ac$ , and draw the line  $EDe$ , making  $Dc$  equal to  $DE$ .

In like manner take the point F in the prolongation of  $Bc$ , and make  $Df$  equal to  $DF$ ; produce  $AD$  and  $ec$  till they meet in  $a$ , and also produce  $BD$  and  $fc$  till they meet in  $b$ : then the distance between the points  $a$  and  $b$  equals the distance between the inaccessible points A and B.

17. *To inscribe any regular polygon in a given circle.* (Fig. 17.)

Divide any diameter AB of the circle ABD into as many equal parts as the polygon is required to have sides; from A and B as centres, with a radius equal to the diameter, describe arcs cutting each other in C; draw the line CD through the second point of division on the diameter AB, and a line drawn from D to B is equal to one side of the polygon required.

18. *To cut a beam of the strongest section from any round piece of timber.* (Fig. 18.)

Divide any diameter CB of the circle into three equal parts; from  $d$  or  $e$ , the two points of division in CB, erect a perpendicular cutting the circumference of the circle in D or A; draw CD and DB, also AC equal to DB and AB equal to CD: the rectangle ABCD will be the section of the beam required.

19. *To describe the proper form of a flat plate by which to construct any given frustum of a cone.* (Fig. 19.)

Let ABCD represent the required frustum of a cone; continue the lines AC and BD till they meet in E; from E as a centre, with ED as radius, describe the arc DH, and from the same centre, with EB as radius, describe the arc BI; make BI equal in length to twice AGB, equal to the circumference of the base of the cone; draw the line EI: then BDHI is the form of the plate required.

FIG. 16.

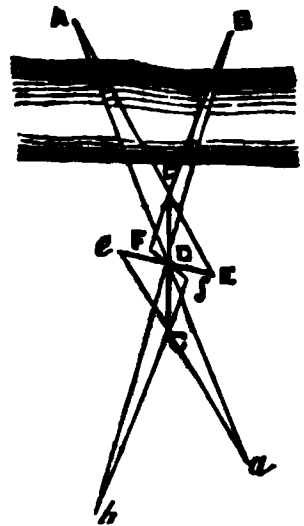


FIG. 17.

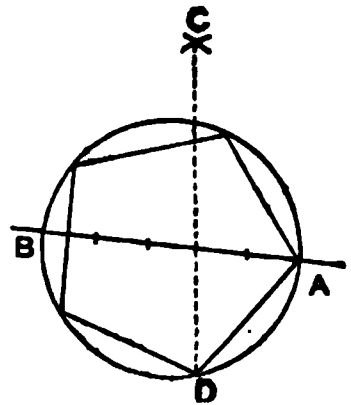


FIG. 18.

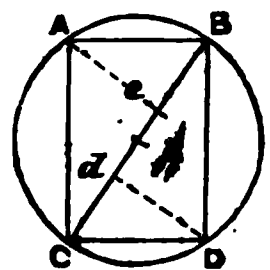
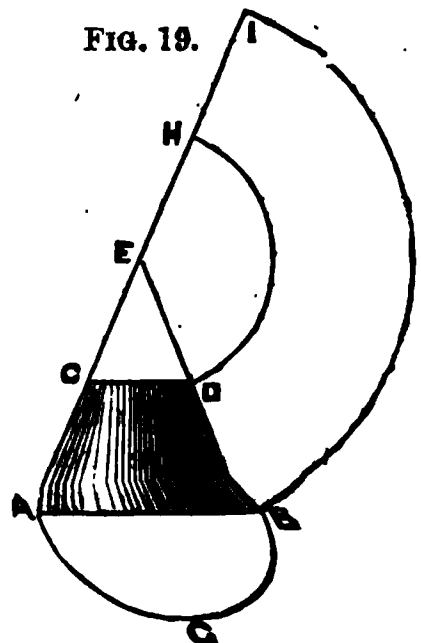
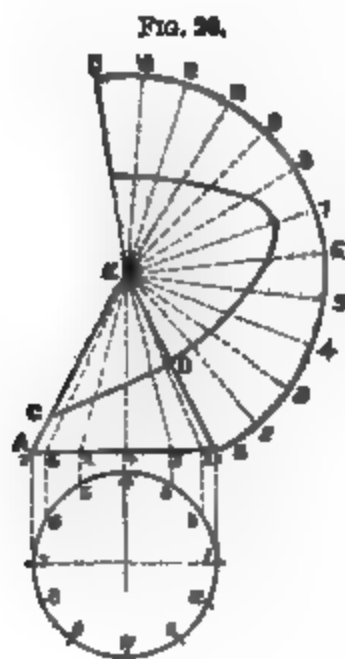


FIG. 19.



20. To find the development of the frustum of a right cone when cut by an angle inclined to the base. (Fig. 20.)



Let  $ABOD$  represent the required frustum of the cone; continue the lines  $AC$  and  $BD$  till they meet in  $E$ ; divide the base of the cone into any number of equal parts—say, 12—in the points 1, 2, 3, &c.; join these points to  $E$ ; next find the development of the base of the cone, as shown in the preceding example, and on it set off the same number of points—viz. 12—and draw lines from them to  $E$ ; then from  $E$  as a centre measure the distance down to the top of the sectional plane  $CD$  at each point of intersection with the lines 1, 2, &c., and set them off on the corresponding numbers (measuring from  $E$ ) in the development: a line drawn through these points will give the curve of the top of the section, as required.

21. To find the development of the frustum of a cylinder when cut by a plane inclined to the base. (Figs. 21 and 22.)

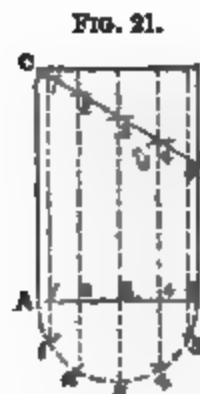


FIG. 22.

Let  $ABCD$  represent the required frustum of a cylinder; divide the base into any number of equal parts—say, 12—and draw lines through those points on the

cylinder parallel to  $AC$  and  $BD$ ; draw a line  $EFG$  equal in length to the circumference of the cylinder, and divide it into the same number of parts; on each point of division set up perpendiculars to it, making  $EH$  and  $GK$  equal in length to  $BD$ , and make  $FI$  equal in length to  $AC$ ; then take the height at 1 and set it up on the corresponding number on each side of  $FI$ , and so on with each number: a line traced through the points thus obtained will be the curve of the required development.



22. *To find the development of any given portion of a segment of a sphere.*

Let  $ABC$  (fig. 23) be the middle section of the segment, and  $CPE$  in the plan (fig. 24) the portion to be developed;

bisect  $AB$  (fig. 23) in  $E$ , and set up the perpendicular  $EC$ ; divide the arc  $AC$  into any given number of equal parts—say, four—and through the points of division draw the lines  $11$ ,  $22$ , &c., parallel to  $AB$ ; on the plan (fig. 24) from  $C$  as a centre, with the radius  $11$  taken from fig. 23, draw the arcs  $11$  cutting  $PC$  and  $QC$  in  $1$  and  $1$ , and so on with  $22$  and  $33$ ;

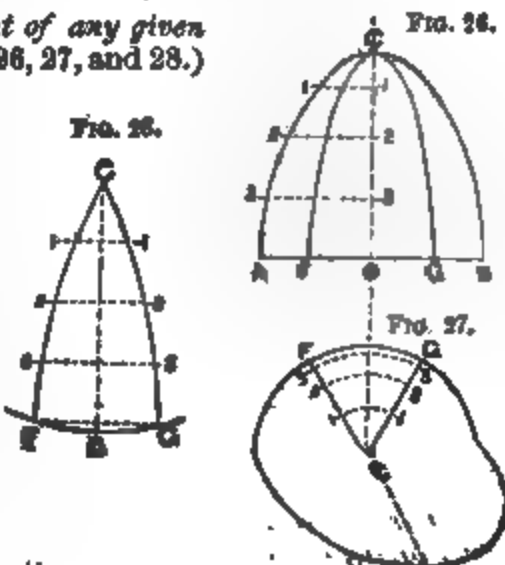
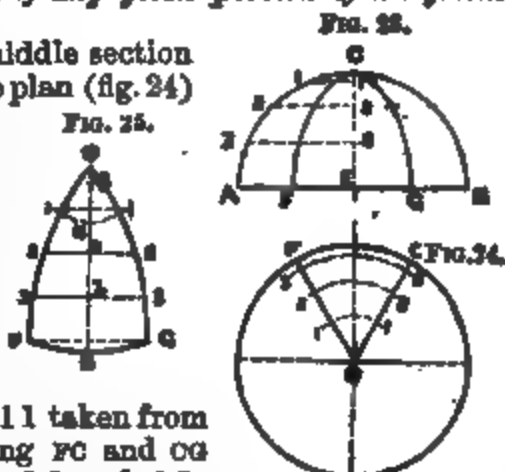
draw any line  $BC$  (fig. 25), making it equal in length to  $BC$  (fig. 23), and on it set off the same number of equal parts; at each point of division draw lines perpendicular to  $BC$ , and number them the same as on fig. 23.

Measure the length of the arc  $11$  in fig. 24, and set off half of it on each side of  $BC$  on line  $11$ , and so on with each arc, including  $FG$ ; a line traced through the points thus obtained will give the curve of the sides of the given portion of the segment when it is developed. To describe the curve at the bottom of the figure, take one-fourth of the circumference of the base as a radius, and from  $F$  and  $G$  as centres describe arcs cutting  $BC$  in  $S$ ; then from  $S$  as centre, with the same radius, describe the arc  $FBG$ , which will be the curve of the bottom of the figure, as required.

Should the top of the figure be cut off at the line  $11$  (fig. 23), from  $S$  as a centre in fig. 25 describe the arc  $1H1$ , which will be the curve of the top of the figure, as required.

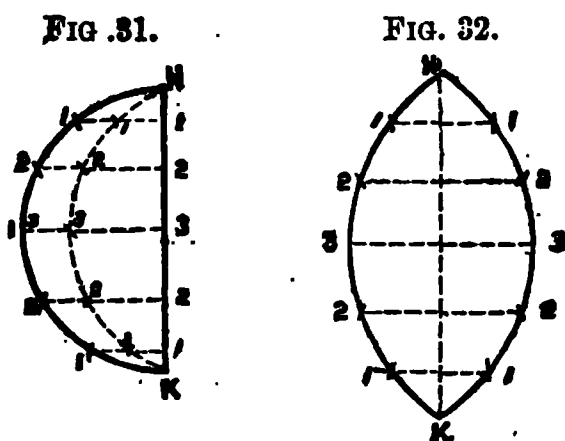
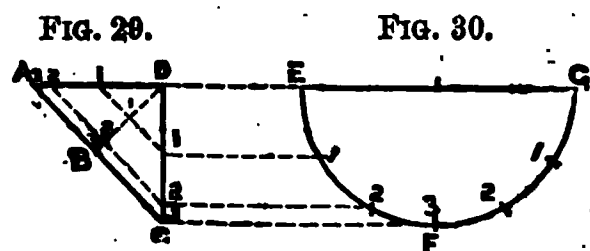
23. *To find the development of any given portion of a paraboloid. (Figs. 26, 27, and 28.)*

The development is found in the same manner as that of a portion of a segment of a sphere, as described in the last example (No. 22), with but one exception—that is, the length of the radius for describing the bottom curve of the figure, which instead of being equal to one-fourth of the circumference, as in example No. 22, is equal to one-half the length of the arc  $AC$  (fig. 26) in this example.



24. To find the development of a table plate for paddle engines.

Let fig. 29 be the side elevation, fig. 30 the front elevation, fig. 31 the plan, and fig. 32 the development of the figure;

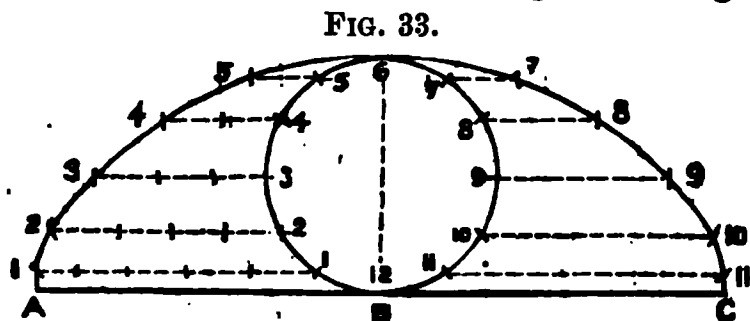


divide EFG (fig. 30) into any number of equal parts—say, six—as shown, to DC (fig. 29); from the points of intersection draw lines parallel to ABC, cutting AD and DC in the points 1, 2, &c.; on AC erect the perpendicular BD; make the line HK (fig. 31) equal in length to EFG (fig. 30), and divide it into the same number of equal parts as that line; then at each point of division erect perpendiculars cutting the arc HIK in the points 1, 2, &c. From fig. 29 take the distance D1 on the line BD,

and set it from the line HK on the perpendiculars 1, 1; then take the distance D2 from fig. 29 in the same way, and apply it on fig. 31 in the same manner, and so on, and from the points thus obtained describe the curve HIK. Draw the line HK (fig. 32) the same length as the arc HIK in fig. 31, and with the same points set off on it as are on the arc HIK; then through each point of division draw lines perpendicular to HK, producing them both ways; number them 1, 2, &c., as on the arc HIK; then from fig. 29, and from the line BD, measure the distance 1 1, and set it off on the line HK (fig. 32) at the corresponding numbers each side of HK; proceed in the same way with all the points in succession: a line traced through the points thus obtained will be the form of the developed surface, as required.

25. To describe a cycloid, the generating circle being given.  
(Fig. 33.)

Let B6 be the generating circle ; draw a line ABC, equal to the circumference of the generating circle, by dividing the



circle into any number of given parts, as 1, 2, 3, &c., and setting off half that number of parts on each side of B; draw lines from the intersections of the circle 1, 2, 3, &c., 7, 8, 9, &c.,

*parallel to AC; set off one division of the circle outwards on the first lines 5 and 7, two divisions on the next lines 4 and 8, then three on the next, and so on: then the intersection of those — on the lines 1, 2, 3, &c., will be points in the curve.*

26. To describe a *prolate cycloid*, the generating circle and the position of the generating point being given. (Fig. 34.)

Let  $5B$  be the generating circle, and  $P$  the generating point; draw the base line  $O10$  equal in length to the circumference of the circle; divide the circle into any number of equal parts—say, 10—and draw the radii 1, 2, 3, &c.; from each of these points in the circle draw lines parallel to  $O10$ ; as in the cycloid, mark off one division on the lines 1 and 9, two divisions on the lines 2 and 8, three on the next, and so on; at the end of each line draw a line parallel to the radius from which it springs, and set on it the distance  $BP$ : a line traced through the points so obtained will be the curve required.

FIG. 34.



27. To draw a *curtate cycloid*, the generating circle and position of the generating point being given. (Fig. 35.)

Let  $AB$  be the generating circle, and  $P$  the generating point without; draw the base line  $FF'$  equal to the circumference of the circle  $AB$ , divide the circumference into any number of equal parts—say, 10—and draw the radii 1, 2, 3, &c.; from each of these points in the circle draw lines parallel to the base line  $FF'$ ; also draw the line  $GG'$  parallel to it, and at the same distance from it as the generating point is from the circle; as in the cycloid, mark off one division on the first line, two on the second, and so on; from the ends of the lines thus found draw lines parallel to the radius from which the line springs, and set off on them the distance  $BP$ : a line traced through the points thus found will be the curve required.

FIG. 35.

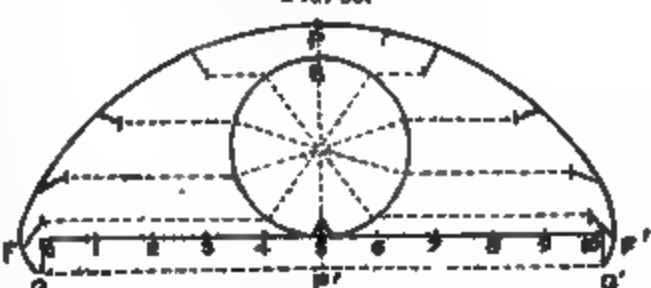
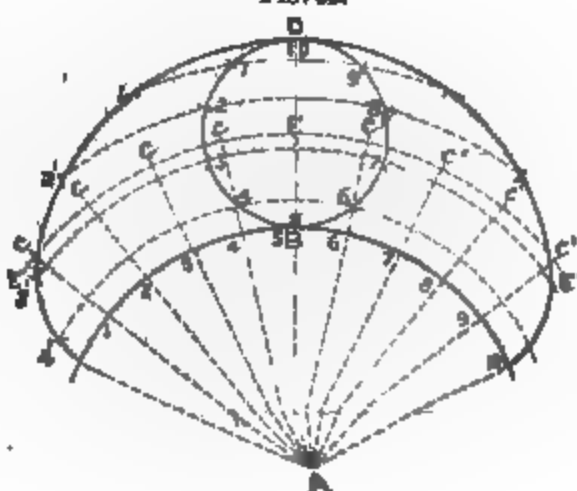


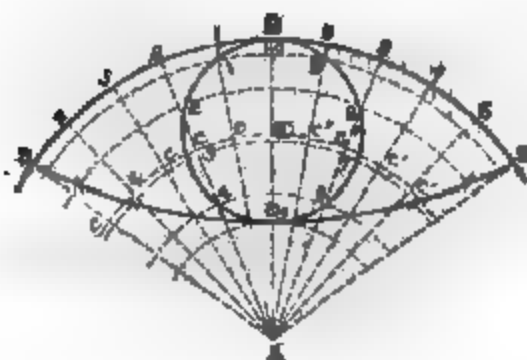
FIG. 36.

28. To describe an *epicycloid*, the generating circle and the directing circle being given. (Fig. 36.)



Let  $BD$  be the generating circle, and  $AE$  the directing circle; divide the generating circle into any number of equal parts—say, 10—as 1, 2, 3, &c., and set off the same distances round the directing circle; draw radial lines from  $A$  through these last points, and produce them to an arc drawn with  $A$  as centre and  $AE$  as radius, as shown by  $cccc$  and  $d'd'd'd'$  on the diagram; draw concentric arcs also through all the points on the generating circle, with  $A$  as centre; then taking  $c, c, c, c$  and  $d', d', d', d'$  as centres, and  $BE$  as radius, describe arcs cutting the concentric circles at  $1', 2', \&c.$ : the points thus found will be points in the required curve.

FIG. 37.



29. To describe a hypocycloid, the generating circle and the directing circle being given. (Fig. 37.)

Proceed as in the epicycloid, the exception being that the construction lines are drawn within the directing circle instead of outside, as in the epicycloid.

30. To draw an arc of a parabola which shall pass through two given points, touch a line at one of those points, and whose axis shall be in a given direction. (Fig. 38.)

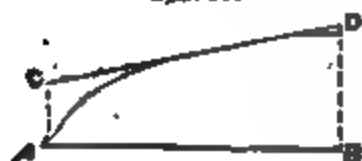
Let  $A$  and  $c$  be the two points,  $AB$  the given tangent, and  $BC$  a line parallel to the given direction of the axis of the parabola, cutting the given tangent in  $B$ ;

FIG. 38.



divide  $AB$  into any number of equal parts, and through the points of division draw lines parallel to  $BC$ ; divide  $BC$  into the same number of parts, and through the points of division draw lines to  $A$ : the points of intersection of 1 and  $1'$ , 2 and  $2'$ , thus found, will be points in the required curve.

FIG. 39.



31. To draw a tangent to any point in a parabola. (Fig. 39.)

From the vertex  $A$  of the parabola draw  $AC$  perpendicular to  $AB$ , and make it equal to half  $BD$ ; through the points  $C$  and  $D$  draw a line, which will be the tangent required.

32. To describe a hyperbola, the diameter, abscissa, and double ordinate being given. (Fig. 40.)

Let  $AB$  be the diameter,  $BC$  its abscissa, and  $DE$  its double ordinate; then through  $B$  draw  $GF$  parallel and equal to  $DE$ ; draw also  $DG$  and  $EF$  parallel to the abscissa  $BC$ .

Divide  $DC$  and  $CE$  into the same number of equal parts, as 1, 2, &c., and from the points of division draw lines meeting in  $A$ .

Divide  $GD$  and  $EF$  each into the same number of parts as  $DC$  or  $CE$ , and from the points of division 1', 2', &c., draw lines meeting in  $B$ .

The points of intersection of the lines 1 and 1', 2 and 2', &c., thus found, will be points in the required curve.

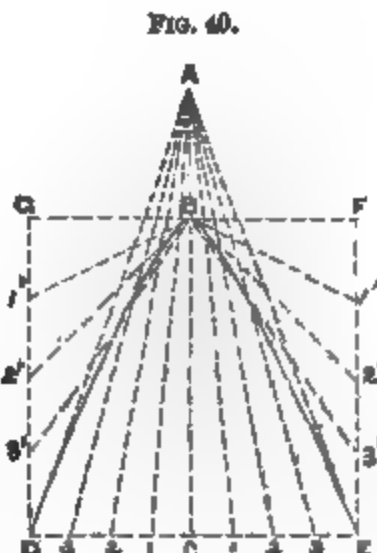


FIG. 40.

33. To construct a noëd curve, the length, extreme half-breadth, and approximate fineness being given. (Fig. 41.)

Let  $BC$  be the extreme half-breadth, and  $CA$  the length.

In  $CA$  take  $CX$  equal to  $CA \times \frac{a}{b}$ , co-efficient of fineness, and at  $X$  set up the ordinate  $XD$  equal to  $\frac{1}{2}$  of  $BC$ .

About  $B$  and through  $D$  describe the circular arc  $FDE$ , cutting  $CB$  produced, in  $E$ .

About  $E$  through  $A$  describe the circular arc  $AF$ , cutting the former arc in  $F$ , which will be the focus.

Through  $F$  draw  $FG$  parallel to  $BC$ .

Join  $FB$  and  $FE$ , and draw  $FH$ , making the angle  $BFH$  equal to the angle  $BFG$ , and cutting  $BC$ , produced if necessary, in  $H$ ; divide the angle  $HFE$  (equal to  $\frac{2}{3}$  of  $BFG$ ) into a convenient number of equal parts by lines diverging from  $F$  and cutting  $HE$  in a series of points, such as  $K$ .

The points  $H$ ,  $B$ , and  $E$  will be three of the points required. About the series of the points thus found describe circular arcs through the focus  $F$ . Divide  $BC$  into the same number of parts as the angle  $HFE$ , and through the points of division draw straight lines parallel to  $CA$ .

The points, such as  $K$ , where these lines cut the arcs re-

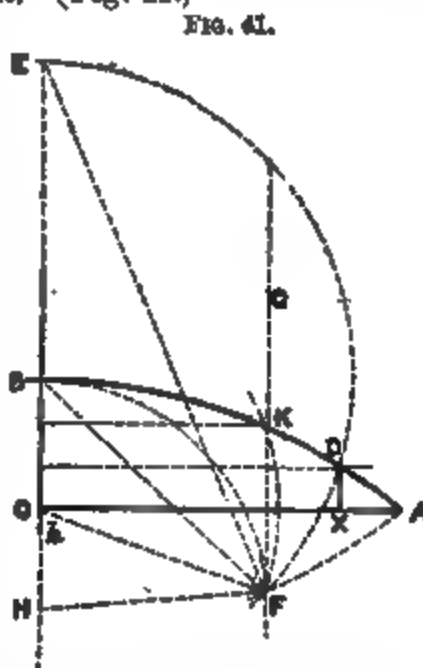


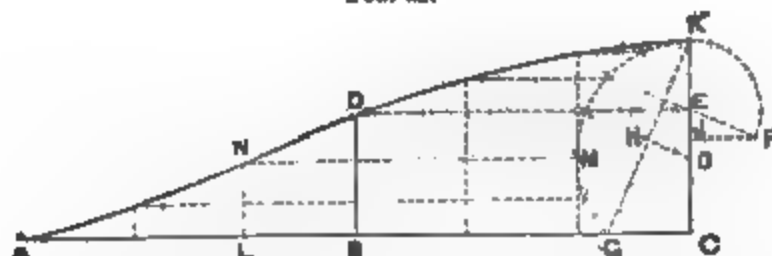
FIG. 41.



spectively corresponding to them, will be points in the required curve.

34. *To construct an harmonic curve.* (Fig. 42.)

FIG. 42.

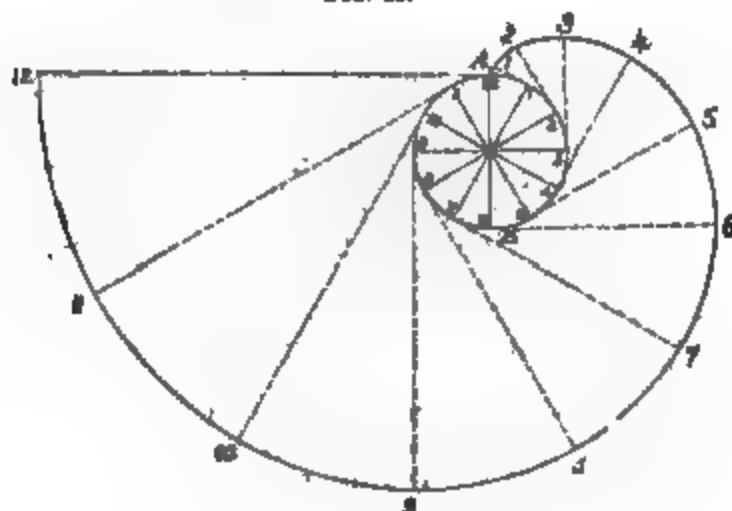


Let AC be the base, CK the greatest ordinate, and BD a balance ordinate midway between AC (the length of this ordinate varies according to the degree of fineness required in the curve, but it should not be greater than  $\frac{2}{3}$ , nor less than  $\frac{1}{3}$ , of CK); then through D parallel to AC draw DE, cutting CK in E; bisect CK in J, through which point draw JF parallel to AC; about E with the radius EK describe a circular arc, cutting JF in F; join FE and produce it, and at right angles to it draw KG.

Bisect KG in H, and from H erect a perpendicular to KG, cutting CK in O, from which as a centre describe the arc KMG; divide the base CA into any number of equal parts, and also divide the arc KMG into the same number of equal parts; through each point of division of the arc, as M, draw lines parallel to AC, and through each point of division of the base, as L, draw perpendiculars cutting the lines parallel to the base: the points of intersection of the lines will be points required in the curve, as N.

35. *To describe the involute of a curve.* (Fig. 43.)

FIG. 43.



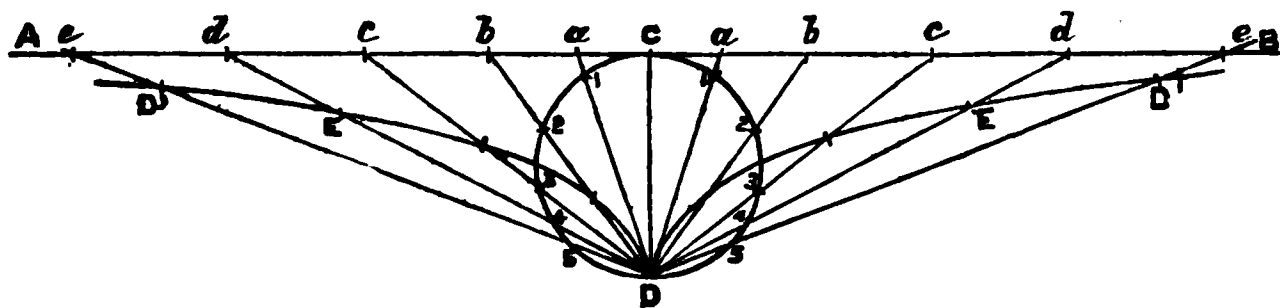
Let AB be the given circle, which divide into any equal number of parts—say, 12—as 1, 2, 3, &c.; from the centre draw

radii to these points; then draw lines (tangents) at right angles to these radii. On the tangent to radius No. 1 set off from the circle a distance equal to one part, and on each of the tangents set off the number of parts corresponding to the number of its radius, so that No. 12 has twelve divisions set off on it (that is, equal to the circumference of the circle): a line traced through the ends of these lines will be the curve required.

36. *To describe a cissoid.* (Fig. 44.)

Draw any line AB, and drop a perpendicular CD from it; on CD describe a circle; from the extremity D of the diameter draw any number of lines, any distance apart, passing through

FIG. 44.

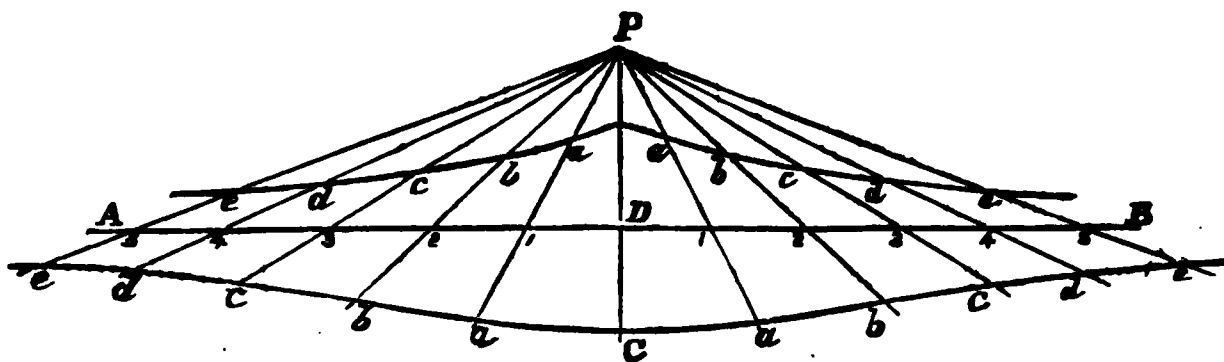


the circle and meeting the line AB in *a*, *b*, *c*, *d*, and *e*; take the length from D to 5, and set it off on the same line on each side from D, as *eD'*; set off the length *d4* from *d*, as *dE*. Proceed thus with all the lines, and trace the curve through the points so obtained.

37. *To describe a conchoid, the asymptote, pole, and diameter being given.* (Fig. 45.)

Let AB be the asymptote, P the pole, and C the diameter; draw CD at right angles to AB; on each side of D set off any number of equal parts, as 1, 2, 3, &c.; from P draw lines passing

FIG. 45.



through the points 1, 2, 3, &c.; then from each of these points with radius CD describe arcs cutting these lines in *a*, *b*, *c*, &c.: the points of intersection will be points in the curve. The curve above the asymptote is called the superior conchoid, and the curve obtained by setting off the same lengths under the asymptote is called the inferior conchoid.



$$\text{sine } A = \frac{\text{perpendicular}}{\text{hypotenuse}} = \frac{PM}{AP}$$

$$\text{co-sine } A = \frac{\text{base}}{\text{hypotenuse}} = \frac{AM}{AP}$$

$$\text{tangent } A = \frac{\text{perpendicular}}{\text{base}} = \frac{PM}{AM}$$

$$\text{co-tangent } A = \frac{\text{base}}{\text{perpendicular}} = \frac{AM}{PM}$$

$$\text{secant } A = \frac{\text{hypotenuse}}{\text{base}} = \frac{AP}{AM}$$

$$\text{co-secant } A = \frac{\text{hypotenuse}}{\text{perpendicular}} = \frac{AP}{PM}$$

$$\text{versed sine } A = 1 - \cos A$$

$$\text{co-versed sine } A = 1 - \sin A.$$

### MEASUREMENT OF ANGLES.

There are three modes of measuring angles, viz.—

- 1st The sexagesimal or English method.
- 2nd. The centesimal or French method:
- 3rd. The circular measure.

The sexagesimal method and the circular measure only will be treated of here.

*The Sexagesimal Method.*—In this method a right angle is supposed to be divided into 90 equal parts, each of which parts is termed a degree; each degree is divided into 60 equal parts, called minutes, and each minute is divided into 60 equal parts, called seconds.

*To express the measure of an angle in degrees and decimal parts of a degree.*

*Ex.:* To bring  $24^{\circ}, 16', 15''$  into the decimal of a degree.

$$\begin{array}{r} 60 \overline{) 15} \text{ seconds} \\ \underline{\phantom{00}25} \text{ of a minute} \\ 60 \overline{) 16.25} \text{ minutes} \\ \underline{\phantom{00}2708} \text{ of a degree.} \end{array}$$

*Answer:*  $24.2708$  degrees.

### THE CIRCULAR MEASURE.

1st. The unit of circular measure is an angle which is subtended at the centre of a circle by an arc equal to the radius of that circle. Such an angle is equal to

$$\frac{2 \text{ right angles}}{\pi} = \frac{180^{\circ}}{3.14159} = 57^{\circ}.2958, \text{ nearly.}$$

2nd. The circular measure of an angle is equal to a fraction

## 22 CIRCULAR MEASURE AND PROPERTIES OF TRIANGLES.

which has for its numerator the arc subtended by that angle at the centre of any circle, and for its denominator the radius of that circle.

*To find the circular measure of any angle expressed in degrees, minutes, and seconds.*

**RULE.**—Multiply the measure of the angle in degrees by  $\pi$ , and divide by 180.

*Ex.:* Express  $12^\circ, 5', 4'' = 43504''$  in circular measure.

$$\frac{(12^\circ 5' 4'') \times \pi}{180} = \frac{43504 \times \pi}{180 \times 60 \times 60} = \frac{2719 \times \pi}{40500} \text{ Answer.}$$

*To find the measure of any angle in degrees, minutes, and seconds, the circular measure being given.*

**RULE.**—Multiply the circular measure of the angle by 180, and divide by  $\pi$ .

*Ex. 1.* Express in degrees, &c., an angle the circular measure of which is  $\frac{2\pi}{3}$ .

$$\frac{2\pi \times 180}{3 \times \pi} = 120^\circ.$$

*Ex. 2.* Express in degrees, &c., an angle the circular measure of which is  $\frac{1}{6}$ .

$$\frac{1}{6} \times \frac{180}{\pi} = \frac{30}{\pi}.$$

### PROPERTIES OF TRIANGLES.

In every triangle the sides are proportional to the sines of the opposite angles.

FIG. 48.

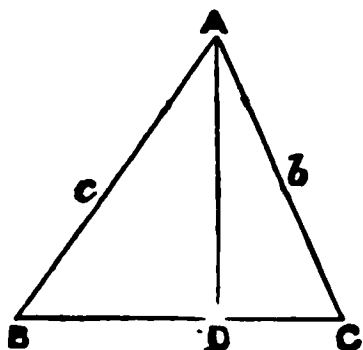


FIG. 49.

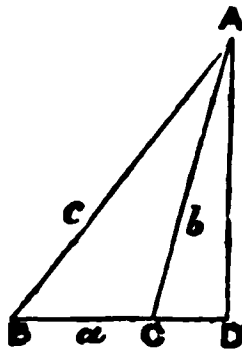
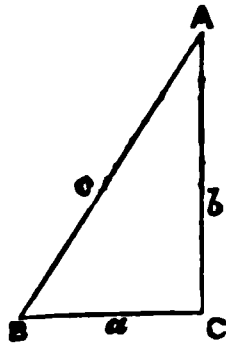


FIG. 50.



*Note.*—The sides opposite the angles A, B, C respectively will be denoted by the letters  $a, b, c$ . The angle BDA in figs. 48 and 49 is supposed to be a right angle.

In fig. 48, where B and C are acute angles, we have—

$$\text{sine B} = \frac{AD}{AB} = \frac{AD}{c}$$

$$\text{sine C} = \frac{AD}{AC} = \frac{AD}{b}$$

$$\therefore \frac{\text{sine B}}{\text{sine C}} = \frac{AD}{c} \div \frac{AD}{b} = \frac{b}{c}.$$

In fig. 49, where  $C$  is an obtuse angle, we have—

$$\sin B = \frac{AD}{AB} = \frac{AD}{c}$$

$$\sin C = \sin (180^\circ - C) = \sin ACD = \frac{AD}{a}$$

$$\therefore \frac{\sin B}{\sin C} = \frac{AD}{c} + \frac{AD}{b} = \frac{b}{c}$$

In fig. 50, where  $C$  is a right angle, we have—

$$\sin B = \frac{b}{c}$$

$$\therefore \frac{\sin B}{\sin C} = \frac{b}{c}$$

And therefore it may be concluded that

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

$$\text{In any triangle } \cos C = \frac{a^2 + b^2 - c^2}{2ab}$$

# SOLUTION OF TRIANGLES.

## *Right-angled Triangles.* (Fig. 51.)

In right-angled triangles—

$$\text{I. Hypotenuse} = \sqrt{(\text{base}^2 + \text{perpendicular}^2)}$$

$$\text{II. Base} = \sqrt{\text{hypotenuse}^2 - \text{perpendicular}^2}$$

$$\text{III. Perpendicular} = \sqrt{\text{hypotenuse}^2 - \text{base}^2}$$

The three angles of every triangle are equal to two right-angled triangles; thus,  $A + B + C = 180^\circ$ .

Of the six elements which compose a triangle—viz. the three angles and the three sides—three must be known in order that the others may be determined, and one of them must be a side—

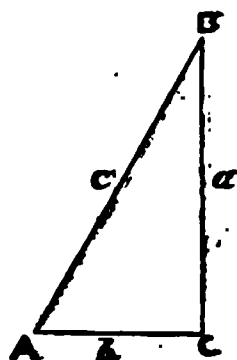
1st. When two sides ( $b, a$ ) and an angle ( $C$ ) are given,

$$\text{I. } \sqrt{c^2 - b^2} = a^2, \text{ from which } a \text{ can be found.}$$

$$\text{II. } \frac{a}{c} = \sin A, \text{ from which } A \text{ can be found.}$$

$$\text{III. } 90^\circ - A, \text{ from which } B \text{ can be found.}$$

FIG. 51.



2nd. When two angles ( $A$ ,  $C$ ) and a side ( $c$ ) are given.

I.  $\frac{a}{c} = \sin A$ , from which we can find  $a$ .

II.  $\frac{b}{c} = \cos A$ , from which we can find  $b$ .

III.  $90^\circ - A$ , from which we can find  $B$ .

*Ex. 1.* Taking the first of the above cases, let

$$b = 5 \quad c = 13 \quad C = 90^\circ.$$

I.  $\sqrt{c^2 - b^2} = \sqrt{169 - 25} = \sqrt{144} = 12 = a$ .

II.  $\frac{a}{c} = \frac{12}{13} = .9230769 = \sin A$ .

From a table of sines we find  $.9230769 = 67^\circ 22' 48''.5$ .

III.  $180^\circ - (A + C) = 180^\circ - 157^\circ 22' 48''.5 = 22^\circ 37' 11''.5$ , or  
 $90^\circ - A = 90^\circ - 67^\circ 22' 48''.5 = 22^\circ 37' 11''.5$ .

*Ex. 2.* Taking the second of the above cases let

$$c = 25 \quad A = 60^\circ \quad C = 90^\circ.$$

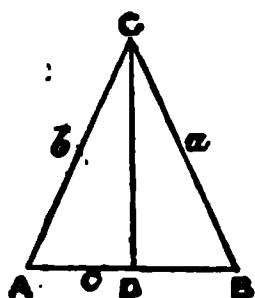
I.  $\frac{a}{c} = \sin A$ ,  $\therefore \frac{a}{25} = \frac{\sqrt{3}}{2}$ ,  $\therefore \frac{25\sqrt{3}}{2} = a = 21.65$ .

II.  $\frac{b}{c} = \cos A$ ,  $\therefore \frac{b}{25} = \frac{1}{2}$ ,  $\therefore \frac{25}{2} = b = 12.5$ .

III.  $180^\circ - (A + C) = 180^\circ - 150 = B = 30^\circ$ .

### *Oblique-angled Triangles. (Fig. 52.)*

FIG. 52.



1. When the three sides  $a$ ,  $b$ ,  $c$  are given.

I.  $\sin \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$

II.  $\cos \frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}$

III.  $\tan \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$

In the above formulæ  $s$  denotes half the sum of the sides.

*Another Method.*—The angles may be found by dividing the triangle, when the sides are given, into two right-angled triangles. In the above figure we have—

$$CD^2 = CA^2 - AD^2, \text{ and also equals } CB^2 - DB^2;$$

$$\text{therefore } CA^2 - CB^2 = AD^2 - DB^2,$$

$$\text{therefore } (CA + CB)(CA - CB) = (AD + DB)(AD - DB).$$

From this we can find  $AD - DB$ , and then, since  $AD + DB$  is known, we can find  $AD$  and  $DB$ ; then

$$\cos A = \frac{AD}{CA}$$

$$\cos B = \frac{DB}{CB}.$$

Thus  $A$  and  $B$  are determined.

2. When two angles ( $A, C$ ) and a side ( $b$ ) are given (fig. 52).

I.  $B = 180^\circ - (A + C)$ , from which we can find  $B$ .

II.  $\frac{a}{b} = \frac{\sin A}{\sin B}$ , from which we can find  $a$ .

III.  $\frac{c}{b} = \frac{\sin C}{\sin B}$ , from which we can find  $c$ .

3. When the two sides  $a, b$  and the angle  $C$  are given (fig. 52).

I.  $c^2 = a^2 + b^2 - 2ab \cdot \cos C$ , from which we can find  $c$ .

II.  $\frac{\sin A}{\sin C} = \frac{a}{c}$ , from which we can find  $A$ .

III.  $180 - (A + C)$ , from which we can find  $B$ .

### EXPRESSIONS FOR THE AREA OF TRIANGLES.

(See fig. 48, 'Properties of Triangles.')

I. Area of triangle  $= \frac{1}{2} BC \cdot AD$ .

and

$$AD = AB \cdot \sin B;$$

therefore area of triangle  $= \frac{1}{2} a \cdot c \cdot \sin B$ .

II. Area of triangle  $= \sqrt{\{s(s-a)(s-b)(s-c)\}}$ .

III. Area of triangle  $= \frac{b^2 \cdot \sin A \cdot \sin C}{2 \sin B}$ .

### MEASUREMENT OF HEIGHTS AND DISTANCES.

1. To find the height of an accessible object. (Fig. 53.)

Let  $BC$  be the object and  $AB$  a line measured horizontally,  $a = AB$ , and  $\theta =$  the angle of elevation, then  $BC = a \cdot \tan \theta =$  height required.

FIG. 53.

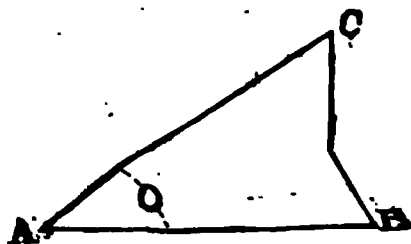
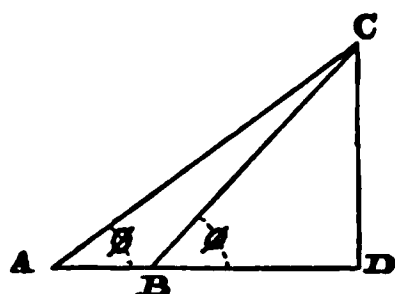




FIG. 54.

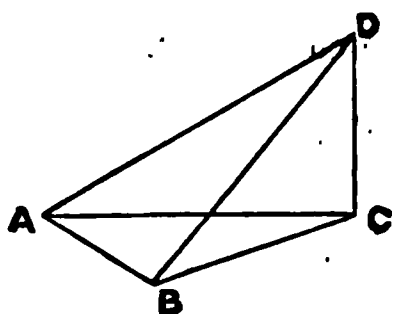


2. To find the height of an inaccessible object on a horizontal plane. (Fig. 54.) ..

Measure a convenient distance AB in the straight line BD, produced, and let  $a = AB$ ; then

$$CD = a \left( \frac{\sin \theta \sin \phi}{\sin (\theta - \phi)} \right).$$

FIG. 55.



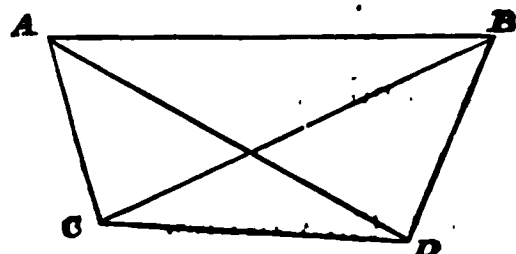
3. To find the height of an inaccessible object when it is not convenient to measure any distances in a line with the base of the object. (Fig. 55.)

Measure the length AB in any direction from A; at A observe the angles DAC and DAB, and at B observe the angles DBA; then

$$DC = AD \cdot \sin DAC, \text{ and } AC = AD \cdot \cos DAC.$$

4. To find the distance between two visible but inaccessible objects. (Fig. 56.)

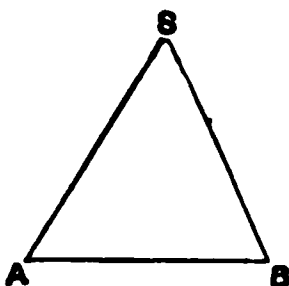
FIG. 56.



Let A and B be the objects; measure a line CD, and suppose A, B, C, D to be in one plane; then observe the angles ACD and ADC, and AC can be found; again observe the angles BCD and BDC, from which BC can be found: thus

knowing AC and BC, and the included angle ACB, AD can be determined.

FIG. 57.



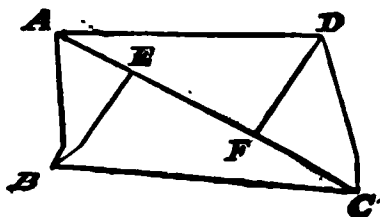
5. To find the distance of a ship from the shore. (Fig. 57.)

Let S be the position of the ship; measure AB, a straight line between two points on the shore; then

$$AS = AB \cdot \frac{\sin SBA}{\sin (SAB + SBA)}.$$

## AREAS OF TRIANGLES, POLYGONS, AND CIRCLES.

FIG. 58.

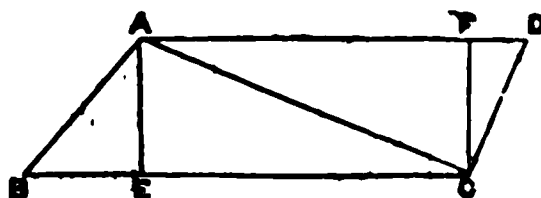


1. The area of any equilateral figure, ABCD (fig. 58),

$$\text{equals } \frac{1}{2} AC (BE + DF).$$

2. The area of any quadrilateral figure (fig. 59), ABCD, two of whose sides, AD and BC, are parallel, equals  $\frac{1}{2}(BC + AD)AE$ , or  $\frac{1}{2}$  (sum of parallel sides)  $\times$  (perpendicular distance between them).

FIG. 59.



3. The area of any quadrilateral figure, ABCF (fig. 59), equals  $\frac{1}{2}(BC \times AE) + \frac{1}{2}(CE \times FC)$ .

4. The area of any triangle, ABC (figs. 60 and 61),

FIG. 60.

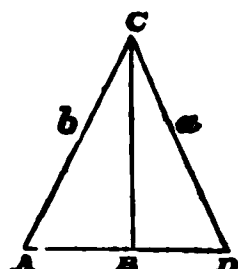
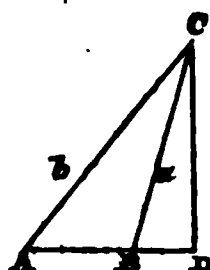


FIG. 61.



equals  $\frac{1}{2}AB \cdot CD = \frac{1}{2}AB \cdot AC \cdot \sin A = \frac{1}{2}a \cdot b \cdot \sin A$ .

5. To find the radii of the inscribed and circumscribed circles of a regular polygon. (Fig. 62.)

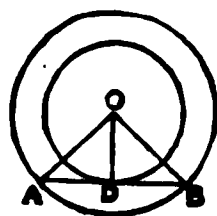
Let AB be the side of a regular polygon of  $n$  sides; let O be the centre of the circles, OD the radius of the inscribed and OA the radius of the circumscribed circle.

Let  $AB = a$ ,  $AO = R$ ,  $OD = r$ , then

$$R = \frac{a}{2 \sin \frac{\pi}{n}},$$

$$r = \frac{a}{2 \tan \frac{\pi}{n}}.$$

FIG. 62.

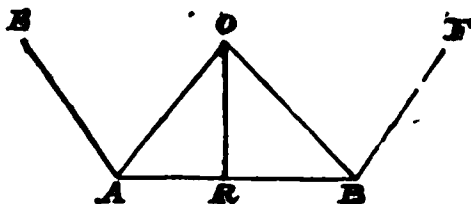


6. To find the area of a regular polygon in terms of its sides. (Fig. 63.)

Let EA, AB, BF be three consecutive sides of a regular polygon of  $n$  sides, and let each side =  $a$ .

Bisect the angles EAB and ABF by the lines OA, OB, meeting in O. Draw OR at right angles to AB.

FIG. 63.



$$\text{Then area of polygon} = \frac{na^2}{4} \cdot \cot \frac{\pi}{n}.$$

TABLE OF THE CIRCULAR MEASURE OF ANY ANGLE (continued).

DEGREES.

Deg.	Circ. Meas.	Day	Circ. Meas.	Day	Circ. Meas.	Day	Circ. Meas.
1	017453295	46	802945145	91	1-58421961	136	2-373647784
2	034906547	47	820304748	92	1-603710291	137	2-391101075
3	052359799	48	837758041	93	1-623156204	138	2-408554368
4	069813170	49	855211383	94	1-640609497	139	2-426007660
5	087266463	50	872664626	95	1-658062789	140	2-443460953
6	104719755	51	890117918	96	1-675516082	141	2-460914245
7	122173048	52	907571211	97	1-692969374	142	2-478367538
8	139626340	53	925024504	98	1-710422667	143	2-495820830
9	157079633	54	942477796	99	1-727875959	144	2-513274123
10	174532925	55	959931089	100	1-745329252	145	2-530727416
11	191986218	56	977384381	101	1-762782545	146	2-548180708
12	209439510	57	994837674	102	1-780235837	147	2-565633900
13	226892803	58	1-012290968	103	1-797689130	148	2-583087293
14	244346095	59	1-029744260	104	1-815142422	149	2-600540585
15	261799388	60	1-047197551	105	1-832595715	150	2-617993878
16	279252680	61	1-064650844	106	1-850049007	151	2-635447170
17	296705973	62	1-082104136	107	1-867502300	152	2-652900463
18	314159265	63	1-099557428	108	1-884955592	153	2-670353756
19	331612558	64	1-117010721	109	1-902408885	154	2-687807048
20	349065850	65	1-134464014	110	1-919862177	155	2-705260340
21	366519143	66	1-151917306	111	1-937315470	156	2-722713633
22	383972435	67	1-169370598	112	1-954768762	157	2-740166926
23	401425728	68	1-186823891	113	1-972222055	158	2-757620218
24	418879020	69	1-204277184	114	1-989675347	159	2-775073511
25	436332313	70	1-221730476	115	2-007128640	160	2-792526803
26	453785606	71	1-239183769	116	2-024581932	161	2-809980096
27	471238898	72	1-256637061	117	2-042035225	162	2-827433388
28	488692191	73	1-274090354	118	2-059488517	163	2-844886681
29	506145483	74	1-291543646	119	2-076941810	164	2-862339973
30	523598776	75	1-308996939	120	2-094395102	165	2-879793266
31	541052068	76	1-326450232	121	2-111848395	166	2-897246558
32	558505361	77	1-343903524	122	2-129301687	167	2-914699851
33	575958653	78	1-361356817	123	2-146754980	168	2-932153143
34	593411946	79	1-378810109	124	2-164208272	169	2-949606436
35	610865238	80	1-396263402	125	2-181661565	170	2-967059728
36	628318531	81	1-413716694	126	2-199114858	171	2-984513021
37	645771823	82	1-431169987	127	2-216568150	172	3-001966313
38	663225116	83	1-448623279	128	2-234021443	173	3-019419606
39	680678408	84	1-466076572	129	2-251474735	174	3-036872898
40	698131701	85	1-483529865	130	2-268928028	175	3-054326191
41	715584993	86	1-500983157	131	2-286381320	176	3-071779484
42	733038286	87	1-518436450	132	2-303834613	177	3-089232776
43	750491578	88	1-535889742	133	2-321287906	178	3-106686069
44	767944871	89	1-553343035	134	2-338741198	179	3-124139361
45	785398163	90	1-570796327	135	2-356194490	180	3-141592654

## TABLE OF THE CIRCULAR MEASURE OF ANY ANGLE (concluded).

## DEGREES.

Deg.	Circ. Meas.	Deg.	Circ. Meas.	Deg.	Circ. Meas.	Deg.	Circ. Meas.
181	3.159045946	226	3.944444110	271	4.729842273	316	5.515240436
182	3.176499239	227	3.961897402	272	4.747295565	317	5.532693729
183	3.193952531	228	3.979350695	273	4.764748858	318	5.550147021
184	3.211405824	229	3.996803987	274	4.782202150	319	5.567600314
185	3.228859116	230	4.014257280	275	4.799655443	320	5.585053606
186	3.246312409	231	4.031710572	276	4.817108736	321	5.602506899
187	3.263765701	232	4.049163865	277	4.834562028	322	5.619960191
188	3.281218994	233	4.066617157	278	4.852015321	323	5.637413484
189	3.298672286	234	4.084070450	279	4.869468613	324	5.654866776
190	3.316125579	235	4.101523742	280	4.886921906	325	5.672320069
191	3.333578871	236	4.118977035	281	4.904375198	326	5.689773362
192	3.351032164	237	4.136430327	282	4.921828491	327	5.707226654
193	3.368485456	238	4.153883620	283	4.939281783	328	5.724679947
194	3.385938749	239	4.171336912	284	4.956735076	329	5.742133239
195	3.403392041	240	4.188790205	285	4.974188368	330	5.759586532
196	3.420845334	241	4.206243497	286	4.991641661	331	5.777039824
197	3.438298626	242	4.223696790	287	5.009094953	332	5.794493117
198	3.455751919	243	4.241150082	288	5.026548246	333	5.811946409
199	3.473205211	244	4.258603375	289	5.044001538	334	5.829399702
200	3.490658504	245	4.276056667	290	5.061454831	335	5.846852994
201	3.508111797	246	4.293509960	291	5.078908123	336	5.864306287
202	3.525565089	247	4.310963252	292	5.096361416	337	5.881759579
203	3.543018382	248	4.328416545	293	5.113814708	338	5.899212872
204	3.560471674	249	4.345869837	294	5.131268001	339	5.916666164
205	3.577924967	250	4.363323130	295	5.148721293	340	5.934119457
206	3.595378259	251	4.380776423	296	5.166174586	341	5.951572749
207	3.612831552	252	4.398229715	297	5.183627878	342	5.969026042
208	3.630284844	253	4.415683008	298	5.201081171	343	5.986479334
209	3.647738137	254	4.433136300	299	5.218534463	344	6.003932627
210	3.665191429	255	4.450589593	300	5.235987756	345	6.021385919
211	3.682644722	256	4.468042885	301	5.253441049	346	6.038839212
212	3.700098014	257	4.485496178	302	5.270894341	347	6.056292504
213	3.717551307	258	4.502949470	303	5.288347633	348	6.073745797
214	3.735004599	259	4.520402763	304	5.305800926	349	6.091199089
215	3.752457892	260	4.537856055	305	5.323254219	350	6.108652382
216	3.769911184	261	4.555309348	306	5.340707511	351	6.126105675
217	3.787364477	262	4.572762640	307	5.358160804	352	6.143558967
218	3.804817769	263	4.590215933	308	5.375614096	353	6.161012260
219	3.822271062	264	4.607669225	309	5.393067389	354	6.178465552
220	3.839724354	265	4.625122518	310	5.410520681	355	6.195918845
221	3.857177647	266	4.642575810	311	5.427973974	356	6.213372137
222	3.874630939	267	4.660029103	312	5.445427266	357	6.230825430
223	3.892084232	268	4.677482395	313	5.462880559	358	6.248278722
224	3.909537524	269	4.694935688	314	5.480333851	359	6.265732015
225	3.926990817	270	4.712388980	315	5.497787144	360	6.283185307

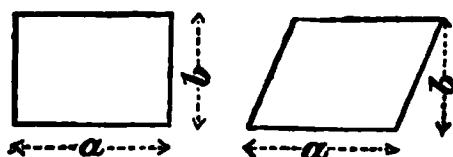
## MENSURATION.

## I. MENSURATION OF SUPERFICIES.

## PROBLEMS.

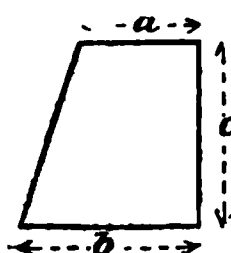
1. To find the area of any parallelogram. (Fig. 67.)

FIG. 67.



RULE.—Multiply the length by the perpendicular height, and the product will be the area. Thus if  $A$  = the area,  $a$  = the length, and  $b$  = the perpendicular height, then  $A = ab$ .

FIG. 68.

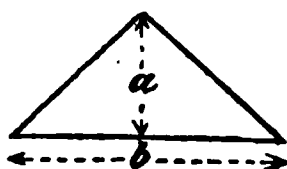


2. To find the area of a trapezoid. (Fig. 68.)

RULE.—Multiply the sum of the parallel sides by the perpendicular distance between them; half the product will be the area. Thus if  $A$  = the area,  $b$  and  $a$  = the parallel sides, and  $c$  = the perpendicular distance between them, then  $A = \frac{(a+b)c}{2}$ .

3. To find the area of any triangle. (Fig. 69.)

FIG. 69.

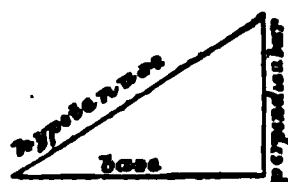


RULE.—Multiply the base by the perpendicular height; half the product will be the area. Thus if  $A$  = the area,  $b$  = the base, and  $a$  = the perpendicular height, then  $A = \frac{ab}{2}$ .

4. To find the third side of a right-angled triangle, two being given. (Fig. 70.)

(I.) When the base and perpendicular are given, to find the hypotenuse, or largest side.

FIG. 70.



RULE.—To the square of the base add the square of the perpendicular; the square root of the sum will equal the hypotenuse.

(II.) When the hypotenuse and one side are given, to find a third side.

RULE.—Multiply the sum of the hypotenuse and one side by their difference; the square root of the product will be the other side.

If  $b$  = the base,  $c$  = the perpendicular, and  $a$  = the hypotenuse, then

$$a = \sqrt{b^2 + c^2}$$

$$b = \sqrt{(a+c)(a-c)} = \sqrt{a^2 - c^2}$$

$$c = \sqrt{(a+b)(a-b)} = \sqrt{a^2 - b^2}$$

5. To find the area of any regular polygon. (Fig. 71.)

RULE.—Multiply the sum of its sides by a perpendicular drawn from the centre of the polygon to one of its sides; half the product will be the area. Thus if  $A$  = the area,  $c$  = the number of sides,  $b$  = the length of one side, and  $a$  = the perpendicular, then  $A = \frac{abc}{2}$ .

Fig. 71.

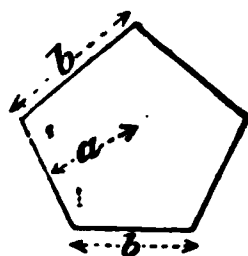


TABLE OF POLYGONS.

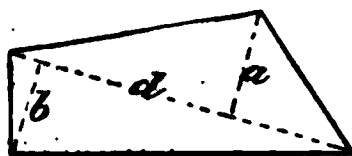
$A$  = the angle contained between any two sides.  
 $R$  = the radius of the circumscribed circle.  
 $r$  = the radius of the inscribed circle.  
 $s$  = the side of the polygon.

No. of Sides	Name	$A$	$R=sx$	$r=sx$	$s=Rx$	$s=rx$	Area= $s^2x$
3	Trigon	$60^\circ$	·57735	·28868	1·73205	3·46410	·43301
4	Tetragon	$90^\circ$	·70711	·50000	1·41421	2·00000	1·00000
5	Pentagon	$108^\circ$	·85065	·68819	1·17557	1·45309	1·72048
6	Hexagon	$120^\circ$	1·00000	·86603	1·00000	1·15470	2·59808
7	Heptagon	$128\frac{1}{2}^\circ$	1·15238	1·03826	·86777	·96315	3·63391
8	Octagon	$135^\circ$	1·30656	1·20711	·76537	·82843	4·82843
9	Nonagon	$140^\circ$	1·46190	1·37374	·68404	·72794	6·18182
10	Decagon	$144^\circ$	1·61863	1·53884	·61803	·64984	7·69421
11	Undecagon	$147\frac{3}{11}^\circ$	1·77473	1·70284	·56347	·58725	9·36564
12	Duodecagon	$150^\circ$	1·93185	1·86603	·51764	·53590	11·19615

6. To find the area of a trapezium. (Fig. 72.)

RULE.—Multiply the diagonal  $d$  by the sum of the two perpendiculars  $a$  and  $b$  let fall upon it from the opposite angles; half the product will be the area. Thus if  $A$  = the area,  $a$  and  $b$  = the perpendiculars, and  $d$  = the diagonal, then

Fig. 72.



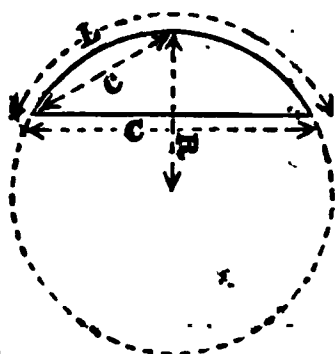
$$A = \frac{(a + b) d}{2}$$

7. To find the circumference of a circle, the diameter being given; or to find the diameter of a circle, the circumference being given.

RULE.—Multiply the diameter by 3·1416, the product will be the circumference; or divide the circumference by 3·1416, the quotient will be the diameter.

## 8. To find the length of any arc of a circle. (Fig. 73.)

FIG. 73.

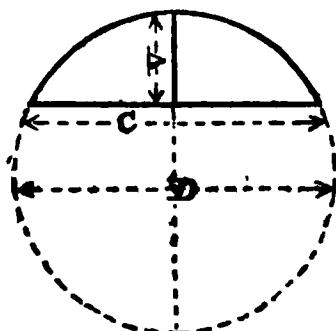


RULE (I.)—From eight times the chord of half the arc subtract the chord of the whole arc; one-third of the remainder will be the length of the arc, nearly. Thus if  $L$  = length of the arc,  $C$  = chord of the whole arc,  $c$  = chord of half the arc, then  $L = \frac{8c - C}{3}$ .

RULE (II.)—The radius being known, multiply together the number of degrees in the arc, the radius, and the number .01745329; the product will be the length of the arc. Thus if  $L$  = length of the arc,  $D$  = degrees in the arc,  $R$  = radius, then

$$L = D \times R \times .01745329.$$

FIG. 74.



## 9. To find the diameter of a circle, the chord and versed sine being given. (Fig. 74.)

RULE.—Divide the square of half the chord by the versed sine, to the quotient add the versed sine, and the sum will be the diameter. Thus if  $D$  = the diameter,  $C$  = the chord, and  $v$  = the versed sine, then

$$D = \left\{ \frac{\left(\frac{C}{2}\right)^2}{v} + v \right\}$$

## 10. To find the area of a circle.

RULE (I.)—Multiply the square of the diameter by .7854, and the product will equal the area, nearly. Thus if  $A$  = the area,  $D$  = the diameter, then  $A = D^2 \times .7854$ .

RULE (II.)—Multiply the square of the circumference by .07958, and the product will be the area. Thus if  $A$  = area,  $C$  = circumference, then  $A = C^2 \times .07958$ .

TABLE OF PROPERTIES OF THE CIRCLE.

$$\pi = 3.14159265358979323846$$

$$\frac{\pi}{2} = 1.57079632679489661923$$

$$\frac{\pi}{4} = .78539816339744830962$$

$$\frac{\pi}{6} = .52359877559829887308$$

$$\pi \sqrt{2} = 4.44288293815836624702$$

$$\pi \sqrt{\frac{1}{2}} = 2.22144146907918312351$$

$$\sqrt{\pi} = 1.77245385090551602730$$

$$\frac{1}{\sqrt{\pi}} = .56418958354775628695$$

$$\sqrt{2} = 1.41421356237309504880$$

$$\sqrt{\frac{1}{2}} = .70710678118654752440$$

$$2\sqrt{\pi} = 3.54490770181103205460$$

$$2\sqrt{\frac{1}{\pi}} = 1.12837916709551257390$$

$$\frac{1}{2}\sqrt{\pi} = .88622692545275801365$$

$$\frac{1}{2}\sqrt{\frac{1}{\pi}} = .07052369794346953587$$

$$2\pi = 6.28318530717958647693$$

$$\frac{2}{\pi} = .63661977236758134308$$

TABLE OF PROPERTIES OF THE CIRCLE (concluded).

In the following formulæ  $A$  = area,  $C$  = circumference,  $D$  = diameter,  $S$  = side of square.

Circumference	$= D \times \pi = R \times 2\pi = \sqrt{A} \times 2\sqrt{\pi}$
Diameter	$= C \times \frac{1}{\pi} = \sqrt{A} \times 2\sqrt{\frac{1}{\pi}}$
Radius	$= C \times \frac{1}{2\pi} = \sqrt{A} \times \sqrt{\frac{1}{\pi}}$
Area	$= R^2 \times \pi = D^2 \times \frac{\pi}{4}$
Side of equal square	$= R \times \sqrt{\pi} = D \times \frac{1}{2}\sqrt{\pi} = C \times \frac{1}{2}\sqrt{\frac{1}{\pi}}$
Side of inscribed square	$= D \times \sqrt{\frac{1}{2}} = C \times \frac{1}{\pi}\sqrt{\frac{1}{2}} = \sqrt{A} \times \sqrt{\frac{2}{\pi}}$
Diameter of equal circle	$= S \times 2\sqrt{\frac{1}{\pi}}$
Diameter of circumscribing circle	$= S \times \sqrt{2}$
Circumference of circumscribing circle	$= S \times \pi\sqrt{2}$
Circumference of equal circle	$= S \times 2\sqrt{\pi}$
Area of inscribed square	$= A \times \frac{2}{\pi}$

11. To find the area of a sector of a circle.

**RULE (I.)**—Multiply the length of the arc by the radius of the sector, and half the product will equal the area.

*Note.*—To find the length of the arc, see problem 8, p. 34.

$A$  = area of sector,  $L$  = length of arc,  $R$  = radius,

$$A = \frac{LR}{2}.$$

**RULE (II.)**—Multiply the number of degrees in the arc by the area of the circle, and  $\frac{1}{360}$  of the product will equal the area. Thus if  $A$  = area,  $D$  = number of degrees in the arc,  $a$  = area of circle, then

$$A = \frac{Da}{360}.$$

12. To find the area of the segment of a circle.

**RULE (I.)**—Find the area of a sector having the same arc as the segment; then deduct the area of the triangle contained between the chord of the segment and the radii of the sector. The remainder will be the area of the segment.

**RULE (II.)**—To two-thirds of the product of the chord and height of the segment, add the cube of the height divided by



twice the chord; the sum will be the area of the segment, nearly. Thus if  $A$  = the area of the segment,  $C$  = the chord, and  $H$  = the height, then

$$A = \left( \frac{2CH}{3} + \frac{H^2}{2C} \right).$$

FIG. 75.

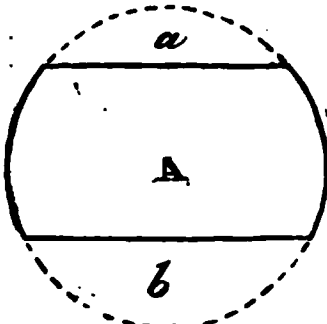


FIG. 76.

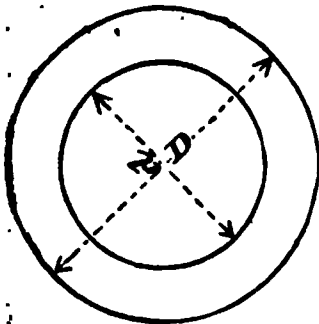
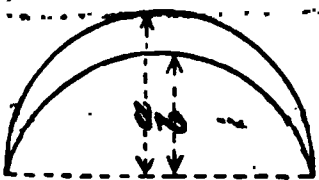
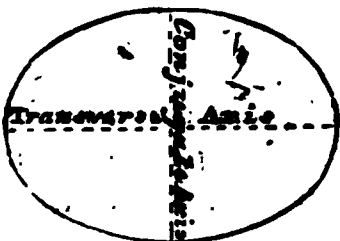


FIG. 77.



16. To find the area of an ellipse. (Fig. 78.)

FIG. 78.



13. To find the area of a circular zone. (Fig. 75.)

RULE.—Find the area of the circle of which the zone forms a part, and from it subtract the sum of the two segments of the circle formed by the zone; the remainder will be the area. Thus if  $A$  = area of the zone,  $a$  and  $b$  = the area of the two segments respectively, and  $C$  = area of the circle, then  $A = C - (a + b)$ .

14. To find the area of a circular ring. (Fig. 76.)

RULE.—Multiply the sum of the inside and outside diameters by their difference, and the result by .7854; the product last obtained will be the area, nearly. Thus if  $A$  = area of ring,  $D$  = diameter of large circle, and  $d$  = diameter of small circle, then

$$A = .7854 \{ (D + d) (D - d) \}.$$

15. To find the area of a lune. (Fig. 77.)

RULE.—Find the areas of the two segments formed by the lune; their difference will be the area required. Thus if  $A$  = area of lune,  $a$  = area of larger segment, and  $b$  = area of smaller segment, then  $A = a - b$ .

RULE.—Multiply together the transverse and conjugate diameters of the ellipse, and the result by .7854; the product will be the area, nearly. Thus if  $A$  = area of ellipse,  $a$  = the conjugate diameter, and  $b$  = the transverse diameter, then

$$A = ab \times .7854.$$

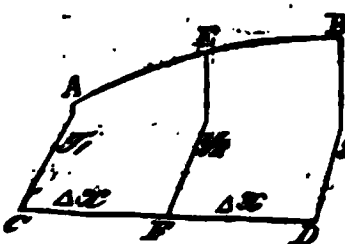
17. To find the area of a cycloid. (Fig. 33.)

RULE.—Multiply the area of its generating circle by 3.

18. To find the area of a parabola.

RULE.—Multiply the base by  $\frac{2}{3}$  of the height. (Fig. 40.)

FIG. 79.



19. To find the area of a common parabola, or a parabola of the second order. (Fig. 79.)

RULE.—To the sum of the two endmost ordinates add four times the intermediate ordinate; multiply the final sum by  $\frac{1}{6}$  of the common interval between the ordinates. The result will be the area. Thus if  $y_1$ ,  $y_2$ , and  $y_3$  be

the ordinates,  $\Delta x$  the common interval, and  $\int y dx$  the area, then

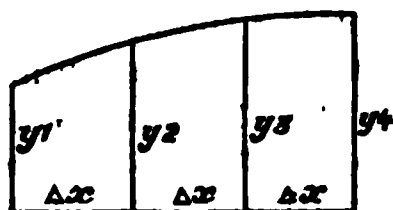
$$\int y dx = \frac{\Delta x}{3} (y_1 + 4y_2 + y_3).$$

*Remark.*—The parabolic curve is said to be of the second order, the third order, &c., according to the exponent of the highest power of the abscissa. Thus a parabola of the first order is a straight line; a common parabola is a parabola of the second order, and so on.

20. To find the area of a parabola of the third order. (Fig. 80.)

**RULE.**—To the sum of the two end-most ordinates add three times the intermediate ordinates; multiply the final sum by  $\frac{3}{8}$  of the common interval between the ordinates: the result will be the area. Thus if  $\int y dx$  = the area, then

FIG. 80.



$$\int y dx = \frac{3 \Delta x}{8} (y_1 + 3y_2 + 3y_3 + y_4).$$

TABLE SHOWING THE MULTIPLIERS FOR THE FOREGOING AND SOME OTHER RULES.

$y_1, y_2, y_3$ , &c. = the ordinates, and  $\Delta x$  = the common interval or abscissa between the ordinates.

1. Trapezoidal rule,

$$\text{Area} = \frac{\Delta x}{2} (y_1 + y_2)$$

2. Rule for parabola of the second order,

$$\text{Area} = \frac{\Delta x}{8} (y_1 + 4y_2 + y_3)$$

3. Rule for parabola of the third order,

$$\text{Area} = \frac{3 \Delta x}{8} (y_1 + 3y_2 + 3y_3 + y_4)$$

4. Rule for parabola of the fourth order,

$$\text{Area} = \frac{2 \Delta x}{45} (7y_1 + 32y_2 + 12y_3 + 32y_4 + 7y_5)$$

5. Rule for parabola of the fifth order,

$$\text{Area} = \frac{5 \Delta x}{288} (19y_1 + 75y_2 + 50y_3 + 50y_4 + 75y_5 + 19y_6)$$

6. Rule for parabola of the sixth order,

$$\text{Area} = \frac{\Delta x}{140} (41y_1 + 216y_2 + 27y_3 + 272y_4 + 27y_5 + 216y_6 + 41y_7)$$

21. To measure any curvilinear area by means of the trapezoidal rule.

RULE.—To the sum of half the two endmost ordinates add all the other ordinates, and multiply the sum by the common interval; the result will be the area. Thus

$$\int y dx = \Delta x \left( \frac{y_1 + y_n}{2} + y_2 + y_3 + \dots + y_{n-1} \right).$$

*Remark.*—In ship-building work it is very often convenient to perform the additions in the above rule mechanically, by measuring off the ordinates continuously on a long strip of paper, and measuring the total length on the proper scale. This rule is only approximate, but it is especially useful for getting the areas of the transverse sections in the first rough calculations of trim, displacement, &c.

22. To measure any curvilinear area by means of the parabolic rule of the second order, or Simpson's first rule.

RULE.—To the sum of the first and last ordinates add four times the intermediate ordinates and twice all the dividing ordinates; multiply the final sum by  $\frac{1}{3}$ , the common interval: the result will be the area. Thus

$$\int y dx = \frac{\Delta x}{3} (y_1 + 4y_2 + 2y_3 + 4y_4 + 2y_5 + \dots + 4y_{n-1} + y_n).$$

*Remark.*—The number of intervals in this rule must be even. The ordinates which separate the parabolas into which the figure is conceived to be divided, are called dividing ordinates, and all the other ordinates except the two endmost ones are called intermediate ordinates.

23. To measure any curvilinear area by means of the parabolic rule of the third order, or Simpson's second rule.

RULE.—To the sum of the two endmost ordinates add three times the intermediate ordinates and twice all the dividing ordinates; multiply the final sum by  $\frac{3}{8}$ , the common interval, and the result will be the area. Thus

$$\int y dx = \frac{3 \Delta x}{8} (y_1 + 3y_2 + 3y_3 + 2y_4 + 3y_5 + \dots + 3y_{n-1} + y_n).$$

The number of intervals in this case must be a multiple of three.

*Remark.*—The sequence of the multipliers in the two foregoing rules is obvious. Thus in the first rule the simple multipliers are 1. 4. 1, but they are combined thus:—

1. 4. 1

1. 4. 1

1. 4. 1

1. 4. 1

1. 4. 1

1. 4. 1

1. 4. 2. 4. 2. 4. 2. 4. 2. 4. 1

In the second rule the multipliers are 1 . 3 . 3 . 1 .

1 . 3 . 3 . 1

1 . 3 . 3 . 1

1 . 3 . 3 . 1 . . . . .

1 . 3 . 3 . 1

1 . 3 . 3 . 1

1 . 3 . 3 . 2 . 3 . 3 . 2 . 3 . 3 . . . . . 3 . 3 . 2 . 3 . 3 . 1

And in the same way the multipliers to measure any curvilinear area may be obtained from the table on p. 37.

24. To measure any curvilinear area when subdivided intervals are used.

1st. When Simpson's first rule is used.

**RULE.**—Diminish the multiplier of each ordinate belonging to a set of subdivided intervals in the same proportion in which the intervals are subdivided. Multiply each ordinate by its respective multiplier as thus found, and treat the sum of their products as if they were whole intervals; that is, multiply the sum thus found by  $\frac{1}{3}$  of a whole interval, and the product will be the area.

2nd. When Simpson's second rule is used.

**RULE.**—Proceed as in the first rule, but multiply by  $\frac{1}{3}$  of a whole interval for the area.

*Example to Simpson's First Rule.*—The series of multipliers for whole intervals being 1 . 4 . 3 . 4 . 2, &c., those for half-intervals will be  $\frac{1}{2}$  . 3 . 1 . 2 . 1, &c., and for quarter-intervals  $\frac{1}{4}$  . 1 .  $\frac{1}{2}$  . 1 .  $\frac{1}{2}$  . &c.

*Remark.*—When an ordinate stands between a larger and a smaller interval, its multiplier will be the sum of the two multipliers which it would have had as an end ordinate for each interval. Thus for an ordinate between a whole and a half interval the multiplier is  $\frac{1}{2} + 1 = 1\frac{1}{2}$ , and between a half and a quarter interval  $\frac{1}{4} + \frac{1}{2} = \frac{3}{4}$ .

TABLE OF MULTIPLIERS WHEN SUBDIVIDED INTERVALS ARE USED.

*Simpson's First Rule.*

|             |               |               |                |                |                |                |                |                |                |                |                |                |                |                |               |
|-------------|---------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------|
| Ordinates   | 0             | 1             | 2              | $2\frac{1}{2}$ | $2\frac{3}{4}$ | 3              | $3\frac{1}{2}$ | $3\frac{3}{4}$ | 4              | 5              | 6              | $6\frac{1}{2}$ | 7              | $7\frac{1}{2}$ | 8             |
| Multipliers | 1             | 4             | $1\frac{1}{2}$ | $1\frac{1}{4}$ | $\frac{2}{5}$  | $1\frac{1}{2}$ | 2              | $1\frac{1}{2}$ | $1\frac{1}{3}$ | 4              | $1\frac{1}{2}$ | 2              | 1              | 2              | $\frac{1}{2}$ |
| Ordinates   | 0             | $\frac{1}{2}$ | 1              | $1\frac{1}{2}$ | 2              | $2\frac{1}{2}$ | 3              | 4              | 5              | $5\frac{1}{2}$ | 6              | $6\frac{1}{2}$ | $6\frac{3}{4}$ | $6\frac{1}{2}$ | 7             |
| Multipliers | $\frac{1}{2}$ | 2             | 1              | 2              | 1              | 2              | $1\frac{1}{2}$ | 4              | $1\frac{1}{2}$ | 2              | $\frac{3}{4}$  | 1              | $\frac{1}{2}$  | 1              | $\frac{1}{4}$ |
| Ordinates   | 0             | 1             | 2              | $2\frac{1}{2}$ | 3              | $3\frac{1}{2}$ | $3\frac{3}{4}$ | $3\frac{1}{2}$ | 4              | $4\frac{1}{2}$ | $4\frac{3}{4}$ | $4\frac{1}{2}$ | $4\frac{3}{8}$ | $4\frac{1}{2}$ | 5             |
| Multipliers | 1             | 4             | $1\frac{1}{2}$ | 2              | $\frac{3}{2}$  | 1              | $\frac{1}{2}$  | 1              | $\frac{3}{12}$ | $\frac{2}{3}$  | $\frac{1}{2}$  | $\frac{2}{3}$  | $\frac{1}{2}$  | $\frac{1}{2}$  | $\frac{2}{3}$ |

| TABLE OF MULTIPLIERS WHEN SUBDIVIDED INTERVALS ARE USED (concluded).<br>Simpson's Second Rule. |   |    |    |    |    |    |    |    |    |    |    |    |    |   |
|--|---|----|----|----|----|----|----|----|----|----|----|----|----|---|
| Ordinates  | 0 | 1  | 2  | 3  | 3½ | 4  | 4½ | 5  | 5½ | 6  | 6½ | 6¾ | 6¾ | 7 |
| Multipliers  | 1 | 3  | 3  | 1½ | 1½ | 1½ | 1  | 1½ | 1½ | 3  | 3  | 1½ | 1½ | 1 |
| Ordinates  | 0 | ½  | ½  | 1  | 1½ | 1½ | 1½ | 2  | 2½ | 2½ | 2½ | 3  | 3½ | 4 |
| Multipliers  | ½ | 1  | 1  | ¾  | ¾  | ¾  | ¾  | 1  | 1  | ¾  | ¾  | ¾  | ¾  | 1 |
| Ordinates  | 0 | ¼  | 1  | 1½ | 2  | 2½ | 3  | 3½ | 3¾ | 4  | 4½ | 4¾ | 4¾ | 5 |
| Multipliers  | ¼ | 1½ | 1½ | 1  | 1½ | 1½ | ¾  | 1  | 1  | ¾  | ¾  | ¾  | ¾  | ¼ |

*Note.*—The ordinates in this table are numbered the same as if they were the number of intervals from the origin.

25. To calculate the area separately of one of the two divisions of a parabolic figure of the second order. (Fig. 81.)

**RULE.**—To eight times the middle ordinate add five times the near end ordinate, and subtract the far end ordinate; multiply the remainder by  $\frac{1}{12}$  the common interval: the result will be the area.

*Note.*—The near end ordinate is the ordinate at the end of the division of which the area is to be found.

FIG. 81.



*Ex.*: In the figure ABCD let it be required to find the area of the division ADEF. Let  $y_1$  = the near end ordinate,  $y_2$  = the middle ordinate, and  $y_3$  = the far end ordinate; then  $\int y dx = \frac{\Delta x}{12} (8y_2 + 5y_1 - y_3)$ .

26. To measure an area bounded by an arc of a plane curve and two radii. (Fig. 82.)

**RULE.**—Divide the angle subtended by the arc into any number of equal angular intervals by means of radii. Measure these radii and compute their half-squares. Treat those half-squares as if they were ordinates of a curve by Simpson's first or second rule, as the number of intervals may require.

FIG. 82.



*Note.*—The common interval must be taken in circular measure. (See pp. 21 and 22.)

*Ex.*: In the figure ABC let  $r_1, r_2, r_3, r_4, r_5$  = the radii,  $\Delta\theta$  = the common angular interval, and  $\int y dx$  = the area; then

$$\int y dx = \frac{(r_1^2 + 4r_2^2 + 2r_3^2 + 4r_4^2 + r_5^2)\Delta\theta}{6}$$

27. *To measure any curved line.* (Fig. 83.)

If the curve is rather irregular, divide it by the eye into any number of circular arcs; join the extremities of each of these arcs by chords. The sum of the length of each of these arcs found by the following rule will be the total length of the curved line.

**RULE.**—Draw a tangent to the curve at each of its extremities; then take the sum of the two distances from the point of intersection of the two tangents to the extremities of the curve, together with twice the length of the chord; divide the result by 3 for the length of the arc.

*Ex.* (fig. 83): Let ACB be one of the arcs, and AB a chord joining the two extremities, and AT, BT' tangents to the curve at its extremities, cutting each other in D; then the length of the curve

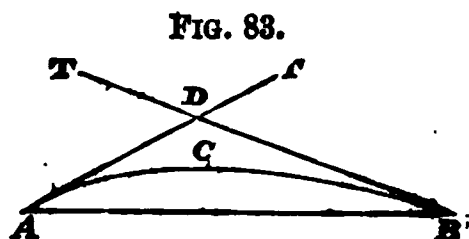


FIG. 83.

$$ACB = \frac{1}{3}(AD + DB + 2AB).$$

## II. MENSURATION OF SOLIDS.

### PROBLEMS.

1. *To find the solidity of any parallelopiped, prism, or cylinder.* (Fig. 84.)

**RULE.**—Multiply the area of the base by the perpendicular height; the result will be the solidity.

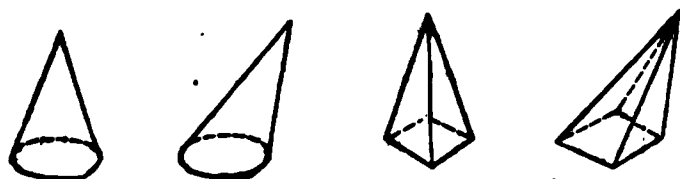
FIG. 84.



2. *To find the solidity of a cone or pyramid.* (Fig. 85.)

**RULE.**—Multiply the area of the base by  $\frac{1}{3}$  the perpendicular height; the product will be the solidity.

FIG. 85.



3. *To find the solidity of the frustum of a cone or pyramid.* (Fig. 86.)

**RULE.**—To the sum of the areas of the two ends add the square root of their product; this final sum being multiplied by  $\frac{1}{3}$  of the perpendicular height will give the solidity.

FIG. 86.



4. To find the solidity of a wedge. (Fig. 87.)

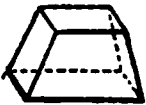
FIG. 87.



RULE.—Add the length of the edge to twice the length of the base; multiply the sum by the width of the base and the product by  $\frac{1}{6}$  of the perpendicular height: the result will be the solidity.

5. To find the solidity of a prismoid. (Fig. 88.)

FIG. 88.



RULE.—To the sum of the areas of the two ends add four times the area of a section parallel to the base and equally distant from both ends; the sum being multiplied by  $\frac{1}{6}$  the perpendicular height will give the solidity.

FIG. 89.



6. To find the solidity of a sphere or globe. (Fig. 89.)

RULE.—Multiply the cube of the diameter by .5236; the product will be the solidity.

7. To find the solidity of the segment of a sphere.

FIG. 90.



(Fig. 90.)

RULE.—Add the square of the height to 3 times the square of the radius of the base; that sum multiplied by the height and that product by .5236 will give the solidity.

FIG. 91.



8. To find the solidity of a zone of a sphere. (Fig. 91.)

RULE.—To the sum of the squares of the radii of the two ends add  $\frac{1}{2}$  the square of the height; multiply the sum by 1.5708: the result will be the solidity.

9. To find the solidity of a cylindrical ring.

RULE.—To the thickness of the ring add the inner diameter; multiply that sum by the square of the thickness, and the product by 2.4674: the result will be the solidity.

TABLE TO FIND THE SOLIDITY AND SURFACE OF ANY REGULAR SOLID.

s = solidity.      A = area.      L = linear edge.  
r = radius of inscribed circle.

| No. of Sides | Name          | $S=L^3 \times$ | $A=L^2 \times$ | $r=L \times$ |
|--------------|---------------|----------------|----------------|--------------|
| 4            | Tetrahedron . | 1.732051       | .117851        | .204124      |
| 6            | Hexahedron .. | 6.000000       | 1.000000       | .500000      |
| 8            | Octahedron .  | 3.464102       | .471405        | .408248      |
| 12           | Dodecahedron  | 20.645729      | 7.663119       | 1.113516     |
| 20           | Icosahedron . | 8.660254       | 2.181695       | .755750      |

10. *To find the solidity of an ellipsoid. (Fig. 92.)*

FIG. 92.

RULE.—Multiply the fixed axis by the square of the revolving one, and the product by  $\cdot 5236$ ; the result will be the solidity.



11. *To find the solidity of the segment of an ellipsoid when the base is circular. (Fig. 93.)*

RULE.—Take double the height of the segment from three times the length of the fixed axis; multiply the difference by the square of the height, and that product by  $\cdot 5236$ ; then that result multiplied by the square of the fixed axis and the product divided by the square of the revolving axis will give the solidity.

FIG. 93.



12. *To find the solidity of the segment of an ellipsoid when the base is elliptical. (Fig. 94.)*

RULE.—Take double the height of the segment from three times the length of the revolving axis; multiply the difference by the square of the height, and that product by  $\cdot 5236$ ; then that result multiplied by the revolving axis, and the product divided by the fixed axis, will give the solidity.

FIG. 94.



13. *To find the solidity of the middle frustum of an ellipsoid when the ends are circular. (Fig. 95.)*

RULE.—Multiply the sum of the square of the middle diameter and the square of the diameter of one end by the length of the frustum, and that product by  $\cdot 5236$  for the solidity.

FIG. 95.



14. *To find the solidity of the middle frustum of an ellipsoid when the ends are elliptical. (Fig. 96.)*

RULE.—To twice the product of the transverse and conjugate diameters of the middle section, add the product of the transverse and conjugate diameters of one end; multiply the sum by the height of the frustum, and that product by  $\cdot 2618$ ; the result will be the solidity.

FIG. 96.



15. *To find the solidity of a paraboloid. (Fig. 97.)*

FIG. 97.

RULE.—Multiply the square of the diameter of the base by the perpendicular height, and the result by  $\cdot 3927$ ; the product will be the solidity.





FIG. 98.



16. *To find the solidity of the frustum of a paraboloid when its ends are perpendicular to its axis.* (Fig. 98.)

RULE.—Multiply the sum of the squares of the diameters of the two ends by the height of the frustum; the product multiplied by  $\cdot 3927$  will be the solidity.

17. *To find the solidity of a hyperboloid.* (Fig. 99.)

FIG. 99.



RULE.—To the square of the radius of the base add the square of the diameter at the middle between the base and the vertex; this sum multiplied by the altitude, and the product by  $\cdot 5236$ , will be the solidity.

18. *To find the solidity of the frustum of a hyperboloid.* (Fig. 100.)

FIG. 100.



RULE.—To the sum of the squares of the semi-diameters of the two ends add the square of the middle diameter; this sum multiplied by the altitude, and the result by  $\cdot 5236$ , will be the solidity.

19. *To measure the volume of a solid bounded on one side by a curved surface.*

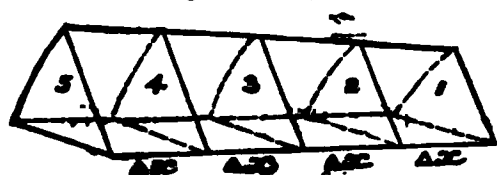
(I.) *To measure the volume in slices.*

RULE.—Take one of the plane surfaces as the base, and divide the mass into slices parallel to that base and sufficiently thin as to be able either to neglect or account separately for the curvature.

Then take the volume of each slice separately, and add them together for the whole volume, taking account of the curvature in this addition if necessary.

(II.) *To measure the volume by the rules applicable to the area of a plane curve.* (Fig. 101.)

FIG. 101.



RULE.—Take a straight line in the figure as a base line, or line of abscissa, and divide the figure along that line into any number of equal parts, and measure the areas of the

plane sections at those points of division by the rules applicable to the area of a plane curve.

Then treat the areas thus found as if they were the ordinates

of a plane curve of the same length as the figure, and the result will be the volume of the solid.

*Example.*

| No. of Sections | Areas of Sections | Multipliers | Products                 |
|-----------------|-------------------|-------------|--------------------------|
| 1               | 5 feet            | 1           | 5                        |
| 2               | 10 feet           | 4           | 40                       |
| 3               | 15 feet           | 2           | 30                       |
| 4               | 20 feet           | 4           | 80                       |
| 5               | 25 feet           | 1           | 25                       |
|                 |                   |             | 180                      |
|                 |                   |             | $\frac{\Delta x}{3} = 2$ |
|                 |                   |             | Area = 360 feet          |

(III.) To measure the volume by Dr. Woolley's method. (Fig. 102.)

**RULE.**—Take a straight line in the figure as a base line, and divide the figure along that line by an odd number of parallel and equidistant planes perpendicular to the base. Then divide the figure horizontally in the same way by a number of plane sections parallel to the base. Then take ordinates at the intersections of the horizontal with the vertical plane sections in their consecutive order, and treat them as follows:—

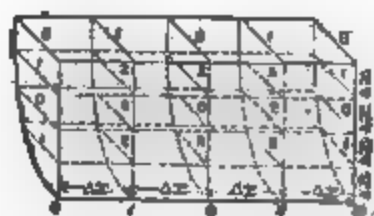
(1) Neglect absolutely all ordinates which are *odd* in *both* planes of section.

(2) Neglecting the outside rows of ordinates, double every ordinate which is *even* in *either* or *both* planes of section, and add them together.

(3) Add to this the simple sum of all the *even* ordinates in the outside rows.

(4) Multiply this final sum by  $\frac{1}{3}$  of the product of the common vertical interval, by the common horizontal interval, and the result will be the volume.

FIG. 102.



*Ex.* In the accompanying figure the multiplier for each ordinate is shown above it, so that if  $S$  = the sum of the products of the ordinates by their respective multipliers,  $V$  = the volume, and  $\Delta x'$  = the common vertical interval, and  $\Delta x$  = the common horizontal interval, then

$$V = \frac{2(S \times \Delta x' \times \Delta x)}{3}$$

20. To measure the volume of a wedge-shaped solid bounded on one side by a curved surface. (Fig. 103.)

RULE.—Divide the figure longitudinally by a number of planes radiating from the edge at equal angular intervals, and also divide the length of figure into a number of equal intervals for ordinates, and treat each of the radiating planes as follows:—



FIG. 103.

(I.) Measure the ordinates as if for taking the areas of the several planes, but instead of the ordinates themselves compute their half-squares, and treat them as if they were the

ordinates of a plane curve of the same length as the figure. The result of this calculation is called the moment of the radiating plane.

(II.) Treat the moments of the radiating planes as if they were the ordinates of a curve, but taking the common angular interval in circular measure.

Example. (See fig. 103.)

| No. of Planes | Moments of the Radiating Planes | Multipliers | Products |
|---------------|---------------------------------|-------------|----------|
| 1             | 105                             | 1           | 105      |
| 2             | 110                             | 4           | 440      |
| 3             | 115                             | 2           | 230      |
| 4             | 120                             | 4           | 480      |
| 5             | 125                             | 1           | 125      |

$$\frac{\theta}{3} = \frac{\text{angular interval}}{3} = \frac{1380}{3} = 460$$

$$\text{Volume} = 460 \times 1590$$

21. To find the mean sectional area of a solid.

RULE.—Divide the volume of the solid by its length; the result will be the mean sectional area.

22. To set off the correct form of a mean cross-section.

RULE.—Divide the figure longitudinally by a number of horizontal planes; take the mean breadth of each of the horizontal planes and set them off perpendicular to a fixed straight line, and at the same height as their corresponding planes in the solid: a line passing through the ends of these mean breadths will be the correct form of the mean sectional area of the solid.

Note.—The mean breadth of a plane curve is found by dividing the area by the length of the curve.

### III. MENSURATION OF THE SURFACES OF SOLIDS

#### PROBLEMS.

1. *To find the slant surface of a cone or pyramid.*

RULE.—Multiply the perimeter of the base by the slant height; half the product will be the convex surface.

2. *To find the convex surface of the frustum of a cone or pyramid.*

RULE.—Multiply the sum of the perimeters of the two ends by the slant height; half the product will be the convex surface.

3. *To find the convex surface of a sphere.*

RULE.—Multiply the circumference by the diameter, or square the diameter and multiply the product by 3.1416; either result will be the convex surface.

4. *To find the convex surface of the segment of a sphere.*

RULE.—Multiply the circumference of the whole sphere by the height of the segment; the product will be the convex surface.

5. *To find the convex surface of the zone of a sphere.*

RULE.—Multiply the circumference of the whole sphere by the height of the zone; the result will be the convex surface.

6. *To find the convex surface of a cylindrical ring.*

RULE.—Multiply the sum of the thickness of the ring and the inner diameter, by the thickness of the ring, and that product by 9.8696; the result will be the convex surface.

7. *To find the mean curved girth of the convex surface of an irregular solid.*

RULE.—Divide the length of the figure into a number of equal parts, and at the points of division measure girths at right angles to the length of the solid; multiply these girths by a proper set of multipliers, applicable to the area of a plane curve; divide the sum of these results by 3, and that quotient by the number of intervals: the last result will be the mean girth.

8. *To find the convex surface of an irregular figure.*

RULE 1.—Multiply the length of the solid by the mean girth.

RULE 2.—Measure the curved girths as if for finding the mean girth; treat those girths as if they were ordinates of a plane curve of the same length as the figure: the result will be the curved surface.

#### PROPOSITION.

*If any plane figure revolve about an axis lying in its own plane, the surface of the solid generated is equal in area to the rectangle whose sides are the length of the perimeter of the generating figure, and the length of the path of the centre of gravity of the perimeter.*

TABLE OF THE CIRCUMFERENCES AND AREAS OF CIRCLES, ADVANCING BY NINES (continued).

| Number | 0            | 1            | 2            | 3            | 4            | 5            | 6            | 7            | 8            | 9            | Number |
|--------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------|
| 40     | Circum. Area | Circum. Area | Circum. Area | Circum. Area | Circum. Area | Circum. Area | Circum. Area | Circum. Area | Circum. Area | Circum. Area | 40     |
| 41     | 125 7 1256 6 | 126 1 1264 5 | 126 4 1272 4 | 126 8 1280 3 | 127 2 1288 2 | 127 6 1296 1 | 128 0 1304 0 | 128 4 1312 0 | 128 8 1320 0 | 129 2 1328 0 | 41     |
| 42     | 126 0 1328 1 | 126 2 1328 3 | 126 6 1336 4 | 127 0 1344 5 | 127 4 1352 6 | 127 8 1360 7 | 128 2 1368 8 | 128 6 1377 0 | 129 0 1385 1 | 129 4 1393 2 | 42     |
| 43     | 126 9 1385 4 | 127 3 1393 7 | 127 7 1402 0 | 128 1 1410 3 | 128 5 1418 6 | 128 9 1427 0 | 129 3 1435 4 | 129 7 1443 8 | 130 1 1452 2 | 130 5 1460 6 | 43     |
| 44     | 127 1 1462 2 | 127 5 1470 7 | 127 9 1479 1 | 128 3 1487 6 | 128 7 1496 1 | 129 1 1504 6 | 129 5 1513 1 | 129 9 1521 6 | 130 3 1530 1 | 130 7 1538 6 | 44     |
| 45     | 127 2 1538 5 | 127 6 1547 0 | 128 0 1555 5 | 128 4 1564 0 | 128 8 1572 5 | 129 2 1581 0 | 129 6 1589 5 | 130 0 1598 0 | 130 4 1606 5 | 130 8 1615 0 | 45     |
| 46     | 127 3 1615 3 | 127 7 1623 8 | 128 1 1632 3 | 128 5 1640 8 | 128 9 1649 3 | 129 3 1657 8 | 129 7 1666 3 | 130 1 1674 8 | 130 5 1683 3 | 130 9 1691 8 | 46     |
| 47     | 127 4 1691 6 | 127 8 1700 1 | 128 2 1708 6 | 128 6 1717 1 | 129 0 1725 6 | 129 4 1734 1 | 129 8 1742 6 | 130 2 1751 1 | 130 6 1759 6 | 131 0 1768 1 | 47     |
| 48     | 127 5 1768 4 | 127 9 1776 9 | 128 3 1785 4 | 128 7 1793 9 | 129 1 1802 4 | 129 5 1810 9 | 129 9 1819 4 | 130 3 1827 9 | 130 7 1836 4 | 131 1 1844 9 | 48     |
| 49     | 127 6 1844 7 | 128 0 1853 2 | 128 4 1861 7 | 128 8 1870 2 | 129 2 1878 7 | 129 6 1887 2 | 130 0 1895 7 | 130 4 1904 2 | 130 8 1912 7 | 131 2 1921 2 | 49     |
| 50     | 127 7 1921 0 | 128 1 1929 5 | 128 5 1938 0 | 128 9 1946 5 | 129 3 1955 0 | 129 7 1963 5 | 130 1 1972 0 | 130 5 1980 5 | 130 9 1989 0 | 131 3 1997 5 | 50     |
| 51     | 127 8 1997 8 | 128 2 2006 3 | 128 6 2014 8 | 129 0 2023 3 | 129 4 2031 8 | 129 8 2040 3 | 130 2 2048 8 | 130 6 2057 3 | 131 0 2065 8 | 131 4 2074 3 | 51     |
| 52     | 127 9 2074 6 | 128 3 2083 1 | 128 7 2091 6 | 129 1 2100 1 | 129 5 2108 6 | 129 9 2117 1 | 130 3 2125 6 | 130 7 2134 1 | 131 1 2142 6 | 131 5 2151 1 | 52     |
| 53     | 128 0 2151 4 | 128 4 2159 9 | 128 8 2168 4 | 129 2 2176 9 | 129 6 2185 4 | 130 0 2193 9 | 130 4 2202 4 | 130 8 2210 9 | 131 2 2219 4 | 131 6 2227 9 | 53     |
| 54     | 128 1 2227 7 | 128 5 2236 2 | 128 9 2244 7 | 129 3 2253 2 | 129 7 2261 7 | 130 1 2270 2 | 130 5 2278 7 | 130 9 2287 2 | 131 3 2295 7 | 131 7 2304 2 | 54     |
| 55     | 128 2 2304 0 | 128 6 2312 5 | 129 0 2321 0 | 129 4 2329 5 | 129 8 2338 0 | 130 2 2346 5 | 130 6 2355 0 | 131 0 2363 5 | 131 4 2372 0 | 131 8 2380 5 | 55     |
| 56     | 128 3 2380 3 | 128 7 2388 8 | 129 1 2397 3 | 129 5 2405 8 | 129 9 2414 3 | 130 3 2422 8 | 130 7 2431 3 | 131 1 2439 8 | 131 5 2448 3 | 131 9 2456 8 | 56     |
| 57     | 128 4 2456 6 | 128 8 2465 1 | 129 2 2473 6 | 129 6 2482 1 | 130 0 2490 6 | 130 4 2499 1 | 130 8 2507 6 | 131 2 2516 1 | 131 6 2524 6 | 132 0 2533 1 | 57     |
| 58     | 128 5 2533 0 | 128 9 2541 5 | 129 3 2550 0 | 129 7 2558 5 | 130 1 2567 0 | 130 5 2575 5 | 130 9 2584 0 | 131 3 2592 5 | 131 7 2601 0 | 132 1 2609 5 | 58     |
| 59     | 128 6 2609 3 | 129 0 2617 8 | 129 4 2626 3 | 129 8 2634 8 | 130 2 2643 3 | 130 6 2651 8 | 131 0 2660 3 | 131 4 2668 8 | 131 8 2677 3 | 132 2 2685 8 | 59     |
| 60     | 128 7 2685 6 | 129 1 2694 1 | 129 5 2702 6 | 129 9 2711 1 | 130 3 2719 6 | 130 7 2728 1 | 131 1 2736 6 | 131 5 2745 1 | 131 9 2753 6 | 132 3 2762 1 | 60     |

TABLE OF THE CIRCUMFERENCES AND AREAS OF CIRCLES, ADVANCING BY 8THS (continued).

| Diam. | 0      |        | $\frac{1}{8}$ |        | $\frac{1}{4}$ |        | $\frac{3}{8}$ |        | $\frac{1}{2}$ |        | $\frac{5}{8}$ |        | $\frac{3}{4}$ |        | $\frac{7}{8}$ |        | Diam. |
|-------|--------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|-------|
|       | Circm. | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   |       |
| 60    | 188.5  | 2827.4 | 188.9         | 2839.2 | 189.3         | 2851.0 | 169.7         | 2862.9 | 190.1         | 2874.8 | 190.5         | 2886.6 | 190.9         | 2898.6 | 191.2         | 2910.5 | 60    |
| 61    | 191.6  | 2922.5 | 192.0         | 2934.5 | 192.4         | 2946.5 | 192.8         | 2958.5 | 193.2         | 2970.6 | 193.6         | 2982.7 | 194.0         | 2994.8 | 194.4         | 3006.9 | 61    |
| 62    | 194.8  | 3019.1 | 195.2         | 3031.3 | 195.6         | 3043.5 | 196.0         | 3055.7 | 196.3         | 3068.0 | 196.7         | 3080.2 | 197.1         | 3092.6 | 197.5         | 3104.9 | 62    |
| 63    | 197.9  | 3117.2 | 198.3         | 3129.6 | 198.7         | 3142.0 | 199.1         | 3154.5 | 199.5         | 3166.9 | 199.9         | 3179.4 | 200.3         | 3191.9 | 200.7         | 3204.4 | 63    |
| 64    | 201.1  | 3217.0 | 201.5         | 3229.6 | 201.8         | 3242.2 | 202.2         | 3254.8 | 202.6         | 3267.5 | 203.0         | 3280.1 | 203.4         | 3292.8 | 203.8         | 3305.6 | 64    |
| 65    | 204.2  | 3318.3 | 204.6         | 3331.1 | 205.0         | 3343.9 | 205.4         | 3356.7 | 205.8         | 3369.6 | 206.2         | 3382.4 | 206.6         | 3395.3 | 207.0         | 3408.3 | 65    |
| 66    | 207.3  | 3421.2 | 207.7         | 3434.2 | 208.1         | 3447.2 | 208.5         | 3460.2 | 208.9         | 3473.2 | 209.3         | 3486.3 | 209.7         | 3499.4 | 210.1         | 3512.5 | 66    |
| 67    | 210.5  | 3525.7 | 210.9         | 3538.8 | 211.3         | 3552.0 | 211.7         | 3565.2 | 212.1         | 3578.5 | 212.5         | 3591.7 | 212.8         | 3605.0 | 213.2         | 3618.4 | 67    |
| 68    | 213.6  | 3631.7 | 214.0         | 3645.1 | 214.4         | 3658.4 | 214.8         | 3671.8 | 215.2         | 3685.3 | 215.6         | 3698.7 | 216.0         | 3712.2 | 216.4         | 3725.7 | 68    |
| 69    | 216.8  | 3739.3 | 217.2         | 3752.8 | 217.6         | 3766.4 | 217.9         | 3780.0 | 218.3         | 3793.7 | 218.7         | 3807.3 | 219.1         | 3821.0 | 219.5         | 3834.7 | 69    |
| 70    | 219.9  | 3848.5 | 220.3         | 3862.2 | 220.7         | 3876.0 | 221.1         | 3889.8 | 221.5         | 3903.6 | 221.9         | 3917.5 | 222.3         | 3931.4 | 222.7         | 3945.3 | 70    |
| 71    | 223.1  | 3959.2 | 223.4         | 3987.2 | 223.8         | 3987.1 | 224.2         | 4001.1 | 224.6         | 4015.2 | 225.0         | 4029.2 | 225.4         | 4043.3 | 225.8         | 4057.4 | 71    |
| 72    | 226.2  | 4071.5 | 226.6         | 4085.7 | 227.0         | 4099.8 | 227.4         | 4114.0 | 227.8         | 4128.2 | 228.2         | 4142.5 | 228.6         | 4156.8 | 228.9         | 4171.1 | 72    |
| 73    | 229.3  | 4185.4 | 229.7         | 4199.7 | 230.1         | 4214.1 | 230.5         | 4228.5 | 230.9         | 4242.9 | 231.3         | 4257.4 | 231.7         | 4271.8 | 232.1         | 4286.3 | 73    |
| 74    | 232.5  | 4300.9 | 232.9         | 4315.4 | 233.3         | 4330.0 | 233.7         | 4344.6 | 234.0         | 4359.2 | 234.4         | 4373.8 | 234.8         | 4388.5 | 235.2         | 4403.2 | 74    |
| 75    | 235.6  | 4417.9 | 236.0         | 4432.6 | 236.4         | 4447.4 | 236.8         | 4462.2 | 237.2         | 4477.0 | 237.6         | 4491.8 | 238.0         | 4506.7 | 238.4         | 4521.5 | 75    |
| 76    | 238.8  | 4536.5 | 239.2         | 4551.4 | 239.5         | 4566.4 | 240.0         | 4581.3 | 240.3         | 4596.3 | 240.7         | 4611.4 | 241.1         | 4626.4 | 241.5         | 4641.5 | 76    |
| 77    | 241.9  | 4656.6 | 242.3         | 4671.8 | 242.7         | 4686.9 | 243.1         | 4702.1 | 243.5         | 4717.3 | 243.9         | 4732.5 | 244.3         | 4747.8 | 244.7         | 4763.1 | 77    |
| 78    | 245.0  | 4778.4 | 245.4         | 4793.7 | 245.8         | 4809.0 | 246.2         | 4824.4 | 246.6         | 4839.8 | 247.0         | 4855.2 | 247.4         | 4870.7 | 247.8         | 4886.2 | 78    |
| 79    | 248.2  | 4901.7 | 248.6         | 4917.2 | 249.0         | 4932.7 | 249.4         | 4948.3 | 249.8         | 4963.9 | 250.1         | 4979.5 | 250.5         | 4995.2 | 250.9         | 5010.9 | 79    |
|       | Circm. | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   | Circm.        | Area   |       |
| 0     |        |        | $\frac{1}{8}$ |        | $\frac{1}{4}$ |        | $\frac{3}{8}$ |        | $\frac{1}{2}$ |        | $\frac{5}{8}$ |        | $\frac{3}{4}$ |        | $\frac{7}{8}$ |        |       |

TABLE OF THE CIRCUMFERENCES AND AREAS OF CIRCLES, ADVANCING BY 8THS (concluded).

| Diam. | 0       |        | $\frac{1}{8}$ |        | $\frac{1}{4}$ |        | $\frac{3}{8}$ |        | $\frac{1}{2}$ |        | $\frac{5}{8}$ |        | $\frac{3}{4}$ |        | $\frac{7}{8}$ |        | Diam. |
|-------|---------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|---------------|--------|-------|
|       | Circum. | Area   | Circum.       | Area   | Circum.       | Area   | Circum.       | Area   | Circum.       | Area   | Circum.       | Area   | Circum.       | Area   | Circum.       | Area   |       |
| 80    | 251.3   | 5026.5 | 251.7         | 5042.3 | 252.1         | 5058.0 | 252.5         | 5073.8 | 252.9         | 5089.6 | 253.3         | 5105.4 | 253.7         | 5121.2 | 254.1         | 5137.1 | 80    |
| 81    | 254.5   | 5153.0 | 254.9         | 5168.9 | 255.3         | 5184.9 | 255.6         | 5200.8 | 256.0         | 5216.8 | 256.4         | 5232.8 | 256.8         | 5248.9 | 257.2         | 5264.9 | 81    |
| 82    | 257.6   | 5281.0 | 258.0         | 5297.1 | 258.4         | 5313.3 | 258.8         | 5329.4 | 259.2         | 5345.6 | 259.6         | 5361.8 | 260.0         | 5378.1 | 260.4         | 5394.3 | 82    |
| 83    | 260.8   | 5410.6 | 261.1         | 5426.9 | 261.5         | 5443.3 | 261.9         | 5459.6 | 262.3         | 5476.0 | 262.7         | 5492.4 | 263.1         | 5508.8 | 263.5         | 5525.3 | 83    |
| 84    | 263.9   | 5541.8 | 264.3         | 5558.3 | 264.7         | 5574.8 | 265.1         | 5591.4 | 265.5         | 5607.9 | 265.9         | 5624.5 | 266.3         | 5641.2 | 266.6         | 5657.8 | 84    |
| 85    | 267.0   | 5674.5 | 267.4         | 5691.2 | 267.8         | 5707.9 | 268.2         | 5724.7 | 268.6         | 5741.5 | 269.0         | 5758.3 | 269.4         | 5775.1 | 269.8         | 5791.9 | 85    |
| 86    | 270.2   | 5808.8 | 270.6         | 5825.7 | 271.0         | 5842.6 | 271.4         | 5859.6 | 271.7         | 5876.5 | 272.1         | 5893.5 | 272.5         | 5910.6 | 272.9         | 5927.6 | 86    |
| 87    | 273.3   | 5944.7 | 273.7         | 5961.8 | 274.1         | 5978.9 | 274.5         | 5996.0 | 274.9         | 6013.2 | 275.3         | 6030.4 | 275.7         | 6047.6 | 276.1         | 6064.9 | 87    |
| 88    | 276.5   | 6082.1 | 276.9         | 6099.4 | 277.2         | 6116.7 | 277.6         | 6134.1 | 278.0         | 6151.4 | 278.4         | 6168.8 | 278.8         | 6186.2 | 279.2         | 6203.7 | 88    |
| 89    | 279.6   | 6221.2 | 280.0         | 6238.6 | 280.4         | 6256.1 | 280.8         | 6273.7 | 281.2         | 6291.2 | 281.6         | 6308.8 | 282.0         | 6326.4 | 282.4         | 6344.1 | 89    |
| 90    | 282.7   | 6361.7 | 283.1         | 6379.4 | 283.5         | 6397.1 | 283.9         | 6414.8 | 284.3         | 6432.6 | 284.7         | 6450.4 | 285.1         | 6468.2 | 285.5         | 6486.0 | 90    |
| 91    | 285.9   | 6503.9 | 286.3         | 6521.8 | 286.7         | 6539.7 | 287.1         | 6557.6 | 287.5         | 6575.5 | 287.8         | 6593.5 | 288.2         | 6611.5 | 288.6         | 6629.6 | 91    |
| 92    | 289.0   | 6647.6 | 289.4         | 6665.7 | 289.8         | 6683.8 | 290.2         | 6701.9 | 290.6         | 6720.1 | 291.0         | 6738.2 | 291.4         | 6756.4 | 291.8         | 6774.7 | 92    |
| 93    | 292.2   | 6793.0 | 292.6         | 6811.2 | 293.0         | 6829.5 | 293.3         | 6847.8 | 293.7         | 6866.1 | 294.1         | 6884.5 | 294.5         | 6902.9 | 294.9         | 6921.3 | 93    |
| 94    | 295.3   | 6939.8 | 295.7         | 6958.2 | 296.1         | 6976.7 | 296.5         | 6995.3 | 296.9         | 7013.8 | 297.3         | 7032.4 | 297.7         | 7051.0 | 298.1         | 7069.6 | 94    |
| 95    | 298.5   | 7088.2 | 298.8         | 7106.9 | 299.2         | 7125.6 | 299.6         | 7144.3 | 300.0         | 7163.0 | 300.4         | 7181.8 | 300.8         | 7200.6 | 301.2         | 7219.4 | 95    |
| 96    | 301.6   | 7238.2 | 302.0         | 7257.1 | 302.4         | 7276.0 | 302.8         | 7294.9 | 303.2         | 7313.8 | 303.6         | 7332.8 | 303.9         | 7351.8 | 304.3         | 7370.8 | 96    |
| 97    | 304.7   | 7389.8 | 305.1         | 7408.9 | 305.5         | 7428.0 | 305.9         | 7447.1 | 306.3         | 7466.2 | 306.7         | 7485.3 | 307.1         | 7504.5 | 307.5         | 7523.7 | 97    |
| 98    | 307.9   | 7543.0 | 308.3         | 7562.2 | 308.7         | 7581.5 | 309.1         | 7600.8 | 309.4         | 7620.1 | 309.8         | 7639.5 | 310.2         | 7658.9 | 310.6         | 7678.3 | 98    |
| 99    | 311.0   | 7697.7 | 311.4         | 7717.2 | 311.8         | 7736.6 | 312.2         | 7756.1 | 312.6         | 7775.6 | 313.0         | 7795.2 | 313.4         | 7814.8 | 313.8         | 7834.4 | 99    |
| Diam. | 0       |        | $\frac{1}{8}$ |        | $\frac{1}{4}$ |        | $\frac{3}{8}$ |        | $\frac{1}{2}$ |        | $\frac{5}{8}$ |        | $\frac{3}{4}$ |        | $\frac{7}{8}$ |        | Diam. |

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS.

| Diam. | Circumferences |         |         |         |         |         |         |         |         |         | Circumferences |         |         |         |         |         |         |         |         |         | Diam.   |
|-------|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|       | 0              | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 0              | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |         |
| 0     | 0.0000         | .3142   | .6283   | .9425   | 1.2566  | 1.5708  | 1.8850  | 2.1991  | 2.5133  | 2.8274  | 0              | 0.0000  | .3142   | .6283   | .9425   | 1.2566  | 1.5708  | 1.8850  | 2.1991  | 2.5133  | 2.8274  |
| 1     | 3.1416         | 3.4557  | 3.7699  | 4.0840  | 4.3982  | 4.7124  | 5.0265  | 5.3407  | 5.6548  | 5.9690  | 1              | 3.1416  | 3.4557  | 3.7699  | 4.0840  | 4.3982  | 4.7124  | 5.0265  | 5.3407  | 5.6548  | 5.9690  |
| 2     | 6.2832         | 6.5973  | 6.9115  | 7.2256  | 7.5398  | 7.8540  | 8.1681  | 8.4823  | 8.7964  | 9.1105  | 2              | 6.2832  | 6.5973  | 6.9115  | 7.2256  | 7.5398  | 7.8540  | 8.1681  | 8.4823  | 8.7964  | 9.1105  |
| 3     | 9.4248         | 9.7389  | 10.0531 | 10.3672 | 10.6814 | 10.9956 | 11.3097 | 11.6239 | 11.9380 | 12.2522 | 3              | 9.4248  | 9.7389  | 10.0531 | 10.3672 | 10.6814 | 10.9956 | 11.3097 | 11.6239 | 11.9380 | 12.2522 |
| 4     | 12.5664        | 12.8805 | 13.1947 | 13.5088 | 13.8230 | 14.1372 | 14.4513 | 14.7655 | 15.0796 | 15.3938 | 4              | 12.5664 | 12.8805 | 13.1947 | 13.5088 | 13.8230 | 14.1372 | 14.4513 | 14.7655 | 15.0796 | 15.3938 |
| 5     | 15.7080        | 16.0221 | 16.3363 | 16.6504 | 16.9646 | 17.2788 | 17.5929 | 17.9071 | 18.2212 | 18.5354 | 5              | 15.7080 | 16.0221 | 16.3363 | 16.6504 | 16.9646 | 17.2788 | 17.5929 | 17.9071 | 18.2212 | 18.5354 |
| 6     | 18.8496        | 19.1637 | 19.4779 | 19.7920 | 20.1062 | 20.4204 | 20.7345 | 21.0487 | 21.3628 | 21.6770 | 6              | 18.8496 | 19.1637 | 19.4779 | 19.7920 | 20.1062 | 20.4204 | 20.7345 | 21.0487 | 21.3628 | 21.6770 |
| 7     | 21.9912        | 22.3053 | 22.6195 | 22.9336 | 23.2478 | 23.5620 | 23.8761 | 24.1903 | 24.5044 | 24.8186 | 7              | 21.9912 | 22.3053 | 22.6195 | 22.9336 | 23.2478 | 23.5620 | 23.8761 | 24.1903 | 24.5044 | 24.8186 |
| 8     | 25.1328        | 25.4469 | 25.7611 | 26.0752 | 26.3894 | 26.7036 | 27.0177 | 27.3319 | 27.6460 | 27.9602 | 8              | 25.1328 | 25.4469 | 25.7611 | 26.0752 | 26.3894 | 26.7036 | 27.0177 | 27.3319 | 27.6460 | 27.9602 |
| 9     | 28.2744        | 28.5885 | 28.9027 | 29.2168 | 29.5310 | 29.8452 | 30.1593 | 30.4735 | 30.7876 | 31.1018 | 9              | 28.2744 | 28.5885 | 28.9027 | 29.2168 | 29.5310 | 29.8452 | 30.1593 | 30.4735 | 30.7876 | 31.1018 |
| 10    | 31.4160        | 31.7301 | 32.0443 | 32.3580 | 32.6726 | 32.9868 | 33.3009 | 33.6150 | 33.9292 | 34.2434 | 10             | 31.4160 | 31.7301 | 32.0443 | 32.3580 | 32.6726 | 32.9868 | 33.3009 | 33.6150 | 33.9292 | 34.2434 |
| 11    | 34.5576        | 34.8717 | 35.1859 | 35.5010 | 35.8142 | 36.1284 | 36.4425 | 36.7567 | 37.0708 | 37.3840 | 11             | 34.5576 | 34.8717 | 35.1859 | 35.5010 | 35.8142 | 36.1284 | 36.4425 | 36.7567 | 37.0708 | 37.3840 |
| 12    | 37.6992        | 38.0133 | 38.3275 | 38.6416 | 38.9558 | 39.2700 | 39.5841 | 39.8983 | 40.2124 | 40.5266 | 12             | 37.6992 | 38.0133 | 38.3275 | 38.6416 | 38.9558 | 39.2700 | 39.5841 | 39.8983 | 40.2124 | 40.5266 |
| 13    | 40.8408        | 41.1549 | 41.4691 | 41.7832 | 42.0974 | 42.4116 | 42.7257 | 43.0399 | 43.3540 | 43.6682 | 13             | 40.8408 | 41.1549 | 41.4691 | 41.7832 | 42.0974 | 42.4116 | 42.7257 | 43.0399 | 43.3540 | 43.6682 |
| 14    | 43.9824        | 44.2965 | 44.6107 | 44.9248 | 45.2390 | 45.5532 | 45.8673 | 46.1815 | 46.4956 | 46.8098 | 14             | 43.9824 | 44.2965 | 44.6107 | 44.9248 | 45.2390 | 45.5532 | 45.8673 | 46.1815 | 46.4956 | 46.8098 |
| 15    | 47.1240        | 47.4381 | 47.7523 | 48.0664 | 48.3806 | 48.6948 | 49.0089 | 49.3231 | 49.6372 | 49.9514 | 15             | 47.1240 | 47.4381 | 47.7523 | 48.0664 | 48.3806 | 48.6948 | 49.0089 | 49.3231 | 49.6372 | 49.9514 |
| 16    | 50.2656        | 50.5797 | 50.8939 | 51.2080 | 51.5224 | 51.8364 | 52.1505 | 52.4647 | 52.7788 | 53.0930 | 16             | 50.2656 | 50.5797 | 50.8939 | 51.2080 | 51.5224 | 51.8364 | 52.1505 | 52.4647 | 52.7788 | 53.0930 |
| 17    | 53.4072        | 53.7213 | 54.0355 | 54.3496 | 54.6638 | 54.9780 | 55.2921 | 55.6063 | 55.9204 | 56.2346 | 17             | 53.4072 | 53.7213 | 54.0355 | 54.3496 | 54.6638 | 54.9780 | 55.2921 | 55.6063 | 55.9204 | 56.2346 |
| 18    | 56.5488        | 56.8629 | 57.1771 | 57.4912 | 57.8054 | 58.1196 | 58.4337 | 58.7479 | 59.0620 | 59.3762 | 18             | 56.5488 | 56.8629 | 57.1771 | 57.4912 | 57.8054 | 58.1196 | 58.4337 | 58.7479 | 59.0620 | 59.3762 |
| 19    | 59.6904        | 60.0045 | 60.3187 | 60.6328 | 60.9470 | 61.2612 | 61.5753 | 61.8895 | 62.2036 | 62.5178 | 19             | 59.6904 | 60.0045 | 60.3187 | 60.6328 | 60.9470 | 61.2612 | 61.5753 | 61.8895 | 62.2036 | 62.5178 |
|       | 0              | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |                | 0       | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |



TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS (continued).

| Diam. | Circumferences |         |         |         |         |         |         |         |         |         | Diam. |
|-------|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
|       | 0              | .1      | .2      | .3      | .4      | .5      | .6      | .7      | .8      | .9      |       |
| 20    | 62.8320        | 63.1461 | 63.4603 | 63.7744 | 64.0886 | 64.4028 | 64.7161 | 65.0311 | 65.3452 | 65.6594 | 20    |
| 21    | 65.9736        | 66.2870 | 66.6012 | 66.9156 | 67.2293 | 67.5444 | 67.8585 | 68.1727 | 68.4868 | 68.8010 | 21    |
| 22    | 69.1152        | 69.4293 | 69.7435 | 70.0576 | 70.3718 | 70.6860 | 71.0001 | 71.3143 | 71.6284 | 71.9426 | 22    |
| 23    | 72.2568        | 72.5709 | 72.8851 | 73.1992 | 73.5134 | 73.8276 | 74.1417 | 74.4559 | 74.7680 | 75.0822 | 23    |
| 24    | 75.3984        | 75.7125 | 76.0267 | 76.3408 | 76.6523 | 76.9632 | 77.2833 | 77.5975 | 77.9116 | 78.2258 | 24    |
| 25    | 78.5400        | 78.8541 | 79.1683 | 79.4824 | 79.7966 | 80.1108 | 80.4249 | 80.7391 | 81.0532 | 81.3674 | 25    |
| 26    | 81.6816        | 82.0099 | 82.3240 | 82.6240 | 82.9382 | 83.2524 | 83.5665 | 83.8807 | 84.1948 | 84.5090 | 26    |
| 27    | 84.8232        | 85.1373 | 85.4515 | 85.7656 | 86.0798 | 86.3940 | 86.7081 | 87.0223 | 87.3364 | 87.6506 | 27    |
| 28    | 87.9648        | 88.2789 | 88.5931 | 88.9072 | 89.2214 | 89.5316 | 89.8497 | 90.1639 | 90.4780 | 90.7922 | 28    |
| 29    | 91.1084        | 91.4205 | 91.7347 | 92.0488 | 92.3630 | 92.6772 | 92.9913 | 93.3055 | 93.6196 | 93.9338 | 29    |
| 30    | 94.2480        | 94.5621 | 94.8763 | 95.1904 | 95.5046 | 95.8188 | 96.1329 | 96.4471 | 96.7612 | 97.0754 | 30    |
| 31    | 97.3896        | 97.7037 | 98.0179 | 98.3320 | 98.6452 | 98.9604 | 99.2745 | 99.5887 | 99.9028 | 100.217 | 31    |
| 32    | 100.531        | 100.845 | 101.160 | 101.474 | 101.748 | 102.102 | 102.416 | 102.730 | 103.044 | 103.359 | 32    |
| 33    | 103.673        | 103.987 | 104.301 | 104.615 | 104.929 | 105.244 | 105.558 | 105.872 | 106.186 | 106.500 | 33    |
| 34    | 106.814        | 107.129 | 107.427 | 107.757 | 108.071 | 108.385 | 108.699 | 109.035 | 109.308 | 109.642 | 34    |
| 35    | 109.936        | 110.270 | 110.584 | 110.898 | 112.213 | 111.527 | 111.841 | 112.155 | 112.469 | 112.783 | 35    |
| 36    | 113.018        | 113.412 | 113.726 | 114.040 | 114.354 | 114.668 | 114.983 | 115.297 | 115.611 | 115.925 | 36    |
| 37    | 116.239        | 116.553 | 116.868 | 117.182 | 117.496 | 117.810 | 118.124 | 118.438 | 118.752 | 119.067 | 37    |
| 38    | 119.381        | 119.695 | 120.009 | 120.323 | 120.637 | 120.952 | 121.266 | 121.580 | 121.894 | 122.208 | 38    |
| 39    | 122.522        | 122.837 | 123.151 | 123.465 | 123.779 | 124.093 | 124.407 | 124.722 | 125.036 | 125.350 | 39    |
| Diam. | 0              | .1      | .2      | .3      | .4      | .5      | .6      | .7      | .8      | .9      | Diam. |



TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS (continued).

| Diam. | Circumferences |         |         |         |         |         |         |         |         |         | Diam. |
|-------|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
|       | .0             | .1      | .2      | .3      | .4      | .5      | .6      | .7      | .8      | .9      |       |
| 60    | 188.496        | 188.810 | 189.124 | 189.438 | 189.753 | 190.067 | 190.381 | 190.695 | 191.009 | 191.323 | 60    |
| 61    | 191.638        | 191.952 | 192.266 | 192.580 | 192.894 | 193.208 | 193.523 | 193.837 | 194.151 | 194.465 | 61    |
| 62    | 194.779        | 195.093 | 195.408 | 195.722 | 196.036 | 196.350 | 196.664 | 196.978 | 197.292 | 197.607 | 62    |
| 63    | 197.921        | 198.235 | 198.549 | 198.863 | 199.177 | 199.492 | 199.806 | 200.120 | 200.434 | 200.748 | 63    |
| 64    | 201.062        | 201.377 | 201.691 | 202.005 | 202.319 | 202.633 | 202.947 | 203.262 | 203.576 | 203.890 | 64    |
| 65    | 204.204        | 204.518 | 204.832 | 205.146 | 205.461 | 205.775 | 206.089 | 206.403 | 206.717 | 207.031 | 65    |
| 66    | 207.346        | 207.660 | 207.974 | 208.288 | 208.602 | 208.916 | 209.231 | 209.545 | 209.859 | 210.173 | 66    |
| 67    | 210.487        | 210.801 | 211.115 | 211.430 | 211.744 | 212.058 | 212.372 | 212.686 | 213.000 | 213.315 | 67    |
| 68    | 213.629        | 213.943 | 214.257 | 214.571 | 214.885 | 215.200 | 215.514 | 215.828 | 216.142 | 216.456 | 68    |
| 69    | 216.770        | 217.083 | 217.399 | 217.713 | 218.027 | 218.341 | 218.655 | 218.970 | 219.284 | 219.598 | 69    |
| 70    | 219.912        | 220.226 | 220.540 | 220.854 | 221.169 | 221.483 | 221.797 | 222.111 | 222.425 | 222.739 | 70    |
| 71    | 223.054        | 223.368 | 223.682 | 223.996 | 224.310 | 224.624 | 224.939 | 225.253 | 225.567 | 225.881 | 71    |
| 72    | 226.195        | 226.509 | 226.824 | 227.138 | 227.452 | 227.766 | 228.080 | 228.394 | 228.708 | 229.023 | 72    |
| 73    | 229.337        | 229.651 | 229.965 | 230.279 | 230.593 | 230.908 | 231.222 | 231.536 | 231.850 | 232.164 | 73    |
| 74    | 232.478        | 232.793 | 233.107 | 233.421 | 233.735 | 234.049 | 234.363 | 234.678 | 234.992 | 235.306 | 74    |
| 75    | 235.620        | 235.934 | 236.248 | 236.562 | 236.877 | 237.191 | 237.505 | 237.819 | 238.133 | 238.447 | 75    |
| 76    | 238.762        | 239.076 | 239.390 | 239.704 | 240.018 | 240.332 | 240.647 | 240.961 | 241.275 | 241.589 | 76    |
| 77    | 241.903        | 242.217 | 242.532 | 242.846 | 243.160 | 243.474 | 243.788 | 244.102 | 244.416 | 244.731 | 77    |
| 78    | 245.045        | 245.359 | 245.673 | 245.987 | 246.301 | 246.616 | 246.930 | 247.244 | 247.548 | 247.872 | 78    |
| 79    | 248.186        | 248.501 | 248.815 | 249.129 | 249.443 | 249.757 | 250.071 | 250.386 | 250.700 | 251.014 | 79    |
|       | .0             | .1      | .2      | .3      | .4      | .5      | .6      | .7      | .8      | .9      |       |

TABLE OF THE CIRCUMSTANCES OF CIRCLES, ADVANCING BY 10THS (concluded).

| Date | Performance |         |         |         |         |         |         |         |         |         | Date |
|------|-------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|------|
|      | 0           | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |      |
| 80   | 251 326     | 251 624 | 251 956 | 252 370 | 252 685 | 252 999 | 253 313 | 253 627 | 253 941 | 254 255 |      |
| 81   | 254 470     | 254 784 | 255 098 | 255 412 | 255 726 | 256 040 | 256 355 | 256 669 | 256 983 | 257 297 |      |
| 82   | 257 611     | 257 925 | 258 240 | 258 554 | 258 868 | 259 182 | 259 496 | 259 810 | 260 124 | 260 439 |      |
| 83   | 260 753     | 261 067 | 261 381 | 261 695 | 262 009 | 262 324 | 262 638 | 262 952 | 263 266 | 263 580 |      |
| 84   | 263 894     | 264 209 | 264 523 | 264 837 | 265 151 | 265 465 | 265 779 | 266 094 | 266 408 | 266 722 |      |
| 85   | 267 036     | 267 350 | 267 664 | 267 978 | 268 293 | 268 607 | 268 921 | 269 235 | 269 549 | 269 863 |      |
| 86   | 270 178     | 270 492 | 270 806 | 271 120 | 271 434 | 271 748 | 272 062 | 272 377 | 272 691 | 273 005 |      |
| 87   | 273 319     | 273 633 | 273 948 | 274 262 | 274 576 | 274 890 | 275 204 | 275 518 | 275 832 | 276 147 |      |
| 88   | 276 461     | 276 775 | 277 089 | 277 403 | 277 717 | 278 032 | 278 346 | 278 660 | 278 975 | 279 289 |      |
| 89   | 279 602     | 279 917 | 280 231 | 280 545 | 280 859 | 281 173 | 281 487 | 281 801 | 282 116 | 282 430 |      |
| 90   | 282 744     | 283 058 | 283 372 | 283 686 | 284 001 | 284 315 | 284 629 | 284 943 | 285 257 | 285 571 |      |
| 91   | 285 886     | 286 200 | 286 514 | 286 829 | 287 142 | 287 456 | 287 771 | 288 086 | 288 399 | 288 713 |      |
| 92   | 289 027     | 289 341 | 289 656 | 289 970 | 290 284 | 290 598 | 290 913 | 291 226 | 291 540 | 291 855 |      |
| 93   | 292 169     | 292 483 | 292 797 | 293 111 | 293 425 | 293 740 | 294 054 | 294 368 | 294 682 | 294 996 |      |
| 94   | 295 310     | 295 625 | 295 939 | 296 254 | 296 567 | 296 881 | 297 195 | 297 510 | 297 824 | 298 138 |      |
| 95   | 298 452     | 298 766 | 299 079 | 299 394 | 299 709 | 300 023 | 300 337 | 300 651 | 300 965 | 301 279 |      |
| 96   | 301 594     | 301 908 | 302 222 | 302 536 | 302 850 | 303 164 | 303 479 | 303 793 | 304 107 | 304 421 |      |
| 97   | 304 735     | 305 049 | 305 364 | 305 678 | 305 992 | 306 306 | 306 620 | 306 934 | 307 248 | 307 562 |      |
| 98   | 307 877     | 308 191 | 308 505 | 308 819 | 309 133 | 309 448 | 309 762 | 310 076 | 310 390 | 310 704 |      |
| 99   | 311 018     | 311 333 | 311 647 | 311 961 | 312 275 | 312 589 | 312 903 | 313 218 | 313 532 | 313 846 |      |

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS (continued).

| Diam. | Circumferences |         |         |         |         |         |         |         |         |         | Diam. |
|-------|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
|       | 0              | .1      | .2      | .3      | .4      | .5      | .6      | .7      | .8      | .9      |       |
| 60    | 188.496        | 188.810 | 189.124 | 189.438 | 189.753 | 190.067 | 190.381 | 190.695 | 191.009 | 191.323 | 60    |
| 61    | 191.638        | 191.952 | 192.266 | 192.580 | 192.894 | 193.208 | 193.523 | 193.837 | 194.151 | 194.465 | 61    |
| 62    | 194.779        | 195.093 | 195.408 | 195.722 | 196.036 | 196.350 | 196.664 | 196.978 | 197.292 | 197.607 | 62    |
| 63    | 197.921        | 198.235 | 198.549 | 198.863 | 199.177 | 199.492 | 199.806 | 200.120 | 200.434 | 200.748 | 63    |
| 64    | 201.062        | 201.377 | 201.691 | 202.005 | 202.319 | 202.633 | 202.947 | 203.262 | 203.576 | 203.890 | 64    |
| 65    | 204.204        | 204.518 | 204.832 | 205.146 | 205.461 | 205.775 | 206.089 | 206.403 | 206.717 | 207.031 | 65    |
| 66    | 207.346        | 207.660 | 207.974 | 208.288 | 208.603 | 208.916 | 209.231 | 209.545 | 209.859 | 210.173 | 66    |
| 67    | 210.487        | 210.801 | 211.116 | 211.430 | 211.744 | 212.058 | 212.372 | 212.686 | 213.000 | 213.315 | 67    |
| 68    | 213.629        | 213.943 | 214.257 | 214.571 | 214.885 | 215.200 | 215.514 | 215.828 | 216.142 | 216.456 | 68    |
| 69    | 216.770        | 217.085 | 217.399 | 217.713 | 218.027 | 218.341 | 218.655 | 218.970 | 219.284 | 219.598 | 69    |
| 70    | 219.912        | 220.226 | 220.540 | 220.854 | 221.169 | 221.483 | 221.797 | 222.111 | 222.425 | 222.739 | 70    |
| 71    | 223.054        | 223.368 | 223.682 | 223.996 | 224.310 | 224.624 | 224.939 | 225.253 | 225.567 | 225.881 | 71    |
| 72    | 226.195        | 226.509 | 226.824 | 227.138 | 227.452 | 227.766 | 228.080 | 228.394 | 228.708 | 229.023 | 72    |
| 73    | 229.337        | 229.651 | 229.965 | 230.279 | 230.593 | 230.908 | 231.222 | 231.536 | 231.850 | 232.164 | 73    |
| 74    | 232.478        | 232.793 | 233.107 | 233.421 | 233.735 | 234.049 | 234.363 | 234.678 | 234.992 | 235.306 | 74    |
| 75    | 235.620        | 235.934 | 236.248 | 236.562 | 236.877 | 237.191 | 237.505 | 237.819 | 238.133 | 238.447 | 75    |
| 76    | 238.762        | 239.076 | 239.390 | 239.704 | 240.018 | 240.332 | 240.647 | 240.961 | 241.275 | 241.599 | 76    |
| 77    | 241.903        | 242.217 | 242.532 | 242.846 | 243.160 | 243.474 | 243.788 | 244.102 | 244.416 | 244.731 | 77    |
| 78    | 245.045        | 245.359 | 245.673 | 245.987 | 246.301 | 246.616 | 246.930 | 247.244 | 247.548 | 247.872 | 78    |
| 79    | 248.186        | 248.501 | 248.815 | 249.129 | 249.443 | 249.757 | 250.071 | 250.386 | 250.700 | 251.014 | 79    |
| Diam. | Circumferences |         |         |         |         |         |         |         |         |         | Diam. |
|       | 0              | .1      | .2      | .3      | .4      | .5      | .6      | .7      | .8      | .9      |       |

TABLE OF THE CIRCUMFERENCE OF CIRCLES, ADVANCING BY 10THS (concluded).

| Diam. | Circumferences |         |         |         |         |         |         |         |         |         | Diam. |
|-------|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
|       | 0              | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |       |
| 80    | 251.328        | 251.624 | 251.956 | 252.270 | 252.585 | 252.899 | 253.213 | 253.527 | 253.841 | 254.155 | 80    |
| 81    | 254.470        | 254.784 | 255.098 | 255.412 | 255.726 | 256.040 | 256.355 | 256.669 | 256.983 | 257.297 | 81    |
| 82    | 257.611        | 257.925 | 258.240 | 258.554 | 258.868 | 259.182 | 259.496 | 259.810 | 260.124 | 260.439 | 82    |
| 83    | 260.753        | 261.067 | 261.381 | 261.695 | 262.009 | 262.324 | 262.638 | 262.952 | 263.264 | 263.580 | 83    |
| 84    | 263.894        | 264.209 | 264.523 | 264.837 | 265.151 | 265.465 | 265.779 | 266.094 | 266.408 | 266.722 | 84    |
| 85    | 267.036        | 267.350 | 267.664 | 267.978 | 268.293 | 268.607 | 268.921 | 269.235 | 269.549 | 269.863 | 85    |
| 86    | 270.178        | 270.492 | 270.806 | 271.120 | 271.434 | 271.748 | 272.067 | 272.377 | 272.691 | 273.005 | 86    |
| 87    | 273.319        | 273.633 | 273.948 | 274.262 | 274.576 | 274.890 | 275.204 | 275.518 | 275.832 | 276.147 | 87    |
| 88    | 276.461        | 276.775 | 277.089 | 277.403 | 277.717 | 278.032 | 278.346 | 278.660 | 278.975 | 279.288 | 88    |
| 89    | 279.602        | 279.917 | 280.231 | 280.545 | 280.859 | 281.173 | 281.487 | 281.803 | 282.116 | 282.430 | 89    |
| 90    | 282.744        | 283.058 | 283.372 | 283.686 | 284.001 | 284.315 | 284.629 | 284.943 | 285.257 | 285.571 | 90    |
| 91    | 285.886        | 286.200 | 286.514 | 286.829 | 287.142 | 287.456 | 287.771 | 288.085 | 288.399 | 288.713 | 91    |
| 92    | 289.027        | 289.341 | 289.656 | 289.970 | 290.284 | 290.598 | 290.912 | 291.226 | 291.540 | 291.855 | 92    |
| 93    | 292.169        | 292.483 | 292.797 | 293.111 | 293.425 | 293.740 | 294.054 | 294.368 | 294.682 | 294.996 | 93    |
| 94    | 295.310        | 295.625 | 295.939 | 296.254 | 296.567 | 296.881 | 297.195 | 297.510 | 297.824 | 298.138 | 94    |
| 95    | 298.452        | 298.766 | 299.072 | 299.384 | 299.709 | 300.023 | 300.337 | 300.651 | 300.965 | 301.279 | 95    |
| 96    | 301.594        | 301.908 | 302.222 | 302.536 | 302.850 | 303.164 | 303.479 | 303.793 | 304.107 | 304.421 | 96    |
| 97    | 304.735        | 305.049 | 305.364 | 305.678 | 305.992 | 306.306 | 306.620 | 306.936 | 307.248 | 307.563 | 97    |
| 98    | 307.877        | 308.191 | 308.505 | 308.819 | 309.133 | 309.448 | 309.762 | 310.076 | 310.396 | 310.704 | 98    |
| 99    | 311.018        | 311.333 | 311.647 | 311.961 | 312.275 | 312.589 | 312.903 | 313.218 | 313.512 | 313.846 | 99    |
| Diam. | 0              | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diam. |

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS.

| Areas  |          |          |          |          |          |          |          |          |          |          |        |          |          |          |          |          |          |          |          |          |          |        |
|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------|
| Diamr. | 0        | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       | Diamr. | 0        | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       | Diamr. |
| 0      | .0000    | .0078    | .0314    | .0706    | .1256    | .1963    | .2827    | .3848    | .5026    | .6361    | 0      | .0000    | .0078    | .0314    | .0706    | .1256    | .1963    | .2827    | .3848    | .5026    | .6361    | 0      |
| 1      | .7854    | .9503    | 1.1309   | 1.3273   | 1.5393   | 1.7671   | 2.0106   | 2.2698   | 2.5446   | 2.8352   | 1      | .7854    | .9503    | 1.1309   | 1.3273   | 1.5393   | 1.7671   | 2.0106   | 2.2698   | 2.5446   | 2.8352   | 1      |
| 2      | 3.1416   | 3.4636   | 3.8013   | 4.1547   | 4.5239   | 4.9087   | 5.3093   | 5.7255   | 6.1575   | 6.6052   | 2      | 3.1416   | 3.4636   | 3.8013   | 4.1547   | 4.5239   | 4.9087   | 5.3093   | 5.7255   | 6.1575   | 6.6052   | 2      |
| 3      | 7.0686   | 7.5476   | 8.0424   | 8.5530   | 9.0792   | 9.6211   | 10.1787  | 10.7521  | 11.3411  | 11.9459  | 3      | 7.0686   | 7.5476   | 8.0424   | 8.5530   | 9.0792   | 9.6211   | 10.1787  | 10.7521  | 11.3411  | 11.9459  | 3      |
| 4      | 12.5664  | 13.2025  | 13.8544  | 14.5220  | 15.2053  | 15.9043  | 16.6190  | 17.3494  | 18.0956  | 18.8574  | 4      | 12.5664  | 13.2025  | 13.8544  | 14.5220  | 15.2053  | 15.9043  | 16.6190  | 17.3494  | 18.0956  | 18.8574  | 4      |
| 5      | 19.6350  | 20.4282  | 21.2372  | 22.0618  | 22.9022  | 23.7583  | 24.6301  | 25.5176  | 26.4208  | 27.3397  | 5      | 19.6350  | 20.4282  | 21.2372  | 22.0618  | 22.9022  | 23.7583  | 24.6301  | 25.5176  | 26.4208  | 27.3397  | 5      |
| 6      | 28.2744  | 29.2247  | 30.1907  | 31.1725  | 32.1699  | 33.1831  | 34.2120  | 35.2566  | 36.3168  | 37.3928  | 6      | 28.2744  | 29.2247  | 30.1907  | 31.1725  | 32.1699  | 33.1831  | 34.2120  | 35.2566  | 36.3168  | 37.3928  | 6      |
| 7      | 38.4846  | 39.5920  | 40.7151  | 41.8539  | 43.0085  | 44.1787  | 45.3647  | 46.5663  | 47.7837  | 49.0168  | 7      | 38.4846  | 39.5920  | 40.7151  | 41.8539  | 43.0085  | 44.1787  | 45.3647  | 46.5663  | 47.7837  | 49.0168  | 7      |
| 8      | 50.2656  | 51.5300  | 52.8102  | 54.1062  | 55.4178  | 56.7451  | 58.0881  | 59.4469  | 60.8213  | 62.2115  | 8      | 50.2656  | 51.5300  | 52.8102  | 54.1062  | 55.4178  | 56.7451  | 58.0881  | 59.4469  | 60.8213  | 62.2115  | 8      |
| 9      | 63.6174  | 65.0389  | 66.4762  | 67.9292  | 69.3979  | 70.8823  | 72.3824  | 73.8982  | 75.4298  | 76.9770  | 9      | 63.6174  | 65.0389  | 66.4762  | 67.9292  | 69.3979  | 70.8823  | 72.3824  | 73.8982  | 75.4298  | 76.9770  | 9      |
| 10     | 78.5400  | 80.1186  | 81.7130  | 83.2320  | 84.9488  | 86.5903  | 88.2475  | 89.9204  | 91.6090  | 93.3133  | 10     | 78.5400  | 80.1186  | 81.7130  | 83.2320  | 84.9488  | 86.5903  | 88.2475  | 89.9204  | 91.6090  | 93.3133  | 10     |
| 11     | 95.0334  | 96.7691  | 98.5205  | 100.2877 | 102.0705 | 103.8691 | 105.6834 | 107.5134 | 109.3590 | 111.2204 | 11     | 95.0334  | 96.7691  | 98.5205  | 100.2877 | 102.0705 | 103.8691 | 105.6834 | 107.5134 | 109.3590 | 111.2204 | 11     |
| 12     | 113.0976 | 114.9904 | 116.8989 | 118.8231 | 120.7631 | 122.7187 | 124.6901 | 126.6771 | 128.6799 | 130.6984 | 12     | 113.0976 | 114.9904 | 116.8989 | 118.8231 | 120.7631 | 122.7187 | 124.6901 | 126.6771 | 128.6799 | 130.6984 | 12     |
| 13     | 132.7326 | 134.7824 | 136.8480 | 138.9294 | 141.0264 | 143.1391 | 145.2675 | 147.4117 | 149.5715 | 151.7471 | 13     | 132.7326 | 134.7824 | 136.8480 | 138.9294 | 141.0264 | 143.1391 | 145.2675 | 147.4117 | 149.5715 | 151.7471 | 13     |
| 14     | 153.9384 | 156.1453 | 158.3680 | 160.6064 | 162.8605 | 165.1303 | 167.4158 | 169.7170 | 172.0340 | 174.3666 | 14     | 153.9384 | 156.1453 | 158.3680 | 160.6064 | 162.8605 | 165.1303 | 167.4158 | 169.7170 | 172.0340 | 174.3666 | 14     |
| 15     | 176.7150 | 179.0790 | 181.4588 | 183.8542 | 186.2654 | 188.6923 | 191.1349 | 193.5932 | 196.0672 | 198.5569 | 15     | 176.7150 | 179.0790 | 181.4588 | 183.8542 | 186.2654 | 188.6923 | 191.1349 | 193.5932 | 196.0672 | 198.5569 | 15     |
| 16     | 201.0624 | 203.5835 | 206.1209 | 208.6723 | 211.1411 | 213.8251 | 216.4248 | 219.0402 | 221.6712 | 224.3189 | 16     | 201.0624 | 203.5835 | 206.1209 | 208.6723 | 211.1411 | 213.8251 | 216.4248 | 219.0402 | 221.6712 | 224.3189 | 16     |
| 17     | 226.9086 | 229.6588 | 232.3527 | 235.0623 | 237.7877 | 240.5287 | 243.2855 | 246.0579 | 248.8461 | 251.6500 | 17     | 226.9086 | 229.6588 | 232.3527 | 235.0623 | 237.7877 | 240.5287 | 243.2855 | 246.0579 | 248.8461 | 251.6500 | 17     |
| 18     | 254.4696 | 257.3048 | 260.1558 | 263.0226 | 265.9050 | 268.8031 | 271.7169 | 274.6465 | 277.5917 | 280.5527 | 18     | 254.4696 | 257.3048 | 260.1558 | 263.0226 | 265.9050 | 268.8031 | 271.7169 | 274.6465 | 277.5917 | 280.5527 | 18     |
| 19     | 283.5294 | 286.5217 | 289.5298 | 292.5536 | 295.5931 | 298.6483 | 301.7192 | 304.8060 | 307.9082 | 311.0252 | 19     | 283.5294 | 286.5217 | 289.5298 | 292.5536 | 295.5931 | 298.6483 | 301.7192 | 304.8060 | 307.9082 | 311.0252 | 19     |
| Diamr. | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       | Diamr. | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       | Diamr. |

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (continued).

| Diamr. | Areas    |          |          |          |          |          |          |           |          |          | Diamr. |
|--------|----------|----------|----------|----------|----------|----------|----------|-----------|----------|----------|--------|
|        | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7        | .8       | .9       |        |
| 20     | 314.1600 | 317.3094 | 320.4746 | 323.6554 | 326.8520 | 330.0643 | 333.2923 | 336.5360  | 339.7954 | 343.0705 | 20     |
| 21     | 346.3614 | 349.6679 | 352.9901 | 356.3281 | 359.6817 | 363.0511 | 366.4362 | 369.8370  | 373.2534 | 376.6856 | 21     |
| 22     | 380.1336 | 383.5972 | 387.0765 | 390.5751 | 394.0823 | 397.6087 | 401.1509 | 404.7087  | 408.2823 | 411.8716 | 22     |
| 23     | 415.4766 | 419.0972 | 422.7336 | 426.3858 | 430.0536 | 433.7371 | 437.4363 | 441.1511  | 444.8819 | 448.6283 | 23     |
| 24     | 452.3904 | 456.1681 | 459.9616 | 463.7708 | 467.5957 | 471.4368 | 475.2926 | 479.1646  | 483.0524 | 486.9558 | 24     |
| 25     | 490.8750 | 494.8098 | 498.7604 | 502.7266 | 506.7086 | 510.7063 | 514.7196 | 518.7488  | 522.7936 | 526.8541 | 25     |
| 26     | 530.9304 | 535.0223 | 539.1299 | 543.2533 | 547.3923 | 551.5471 | 555.7176 | 559.9038  | 564.1056 | 568.3232 | 26     |
| 27     | 572.5566 | 576.8056 | 581.0703 | 585.3507 | 589.6469 | 593.9587 | 598.2868 | 602.6295  | 606.9885 | 611.3632 | 27     |
| 28     | 615.7536 | 620.1596 | 624.5814 | 629.0190 | 633.4722 | 637.9411 | 642.4257 | 646.9261  | 651.4421 | 655.9739 | 28     |
| 29     | 660.5214 | 665.0845 | 669.6634 | 674.2580 | 678.8683 | 683.4948 | 688.1360 | 692.7934  | 697.4666 | 702.1554 | 29     |
| 30     | 706.8600 | 711.5802 | 716.3162 | 721.0678 | 725.8352 | 730.6183 | 735.4171 | 740.2316  | 745.0618 | 749.9077 | 30     |
| 31     | 754.7694 | 759.6467 | 764.5397 | 769.4485 | 774.3729 | 779.3131 | 784.2689 | 789.2406  | 794.2278 | 799.2308 | 31     |
| 32     | 804.2496 | 809.2840 | 814.3341 | 819.3999 | 824.4815 | 829.5787 | 834.6917 | 839.8203  | 844.9647 | 850.1248 | 32     |
| 33     | 855.3006 | 860.4920 | 865.6992 | 870.9222 | 876.1608 | 881.4151 | 886.6851 | 891.9709  | 897.2723 | 902.5895 | 33     |
| 34     | 907.9224 | 913.2709 | 918.6352 | 924.0115 | 929.4109 | 934.8223 | 940.2494 | 945.6922  | 951.1508 | 956.6250 | 34     |
| 35     | 962.1150 | 967.6206 | 973.1420 | 978.6790 | 984.2318 | 989.8003 | 995.3845 | 1000.984  | 1006.600 | 1012.231 | 35     |
| 36     | 1017.878 | 1023.541 | 1029.220 | 1034.913 | 1040.624 | 1046.349 | 1052.090 | 1057.8474 | 1063.620 | 1069.408 | 36     |
| 37     | 1075.213 | 1081.032 | 1086.868 | 1092.719 | 1098.586 | 1104.469 | 1110.367 | 1116.281  | 1122.211 | 1128.156 | 37     |
| 38     | 1134.118 | 1140.095 | 1146.087 | 1152.095 | 1158.119 | 1164.159 | 1170.215 | 1176.286  | 1182.373 | 1188.465 | 38     |
| 39     | 1194.539 | 1200.727 | 1206.877 | 1213.042 | 1219.224 | 1225.420 | 1231.633 | 1237.861  | 1244.121 | 1250.365 | 39     |
| Diamr. | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7        | .8       | .9       | Diamr. |



TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (continued).

| Diamr. | Areas    |          |          |          |          |          |          |          |          |          | Diamr. |
|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------|
|        | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       |        |
| 40     | 1256.640 | 1262.931 | 1269.239 | 1275.560 | 1281.898 | 1288.252 | 1294.622 | 1301.007 | 1307.408 | 1313.825 | 40     |
| 41     | 1320.257 | 1326.706 | 1333.169 | 1339.649 | 1346.144 | 1352.655 | 1359.182 | 1365.724 | 1372.282 | 1378.856 | 41     |
| 42     | 1385.446 | 1392.051 | 1398.672 | 1405.308 | 1411.961 | 1418.629 | 1425.313 | 1432.012 | 1438.727 | 1445.458 | 42     |
| 43     | 1452.205 | 1458.967 | 1465.745 | 1472.539 | 1479.348 | 1486.173 | 1493.014 | 1499.871 | 1506.743 | 1513.629 | 43     |
| 44     | 1520.534 | 1527.454 | 1534.389 | 1541.340 | 1548.306 | 1555.288 | 1562.286 | 1569.300 | 1576.329 | 1583.374 | 44     |
| 45     | 1590.435 | 1597.511 | 1604.604 | 1611.711 | 1618.835 | 1625.974 | 1633.129 | 1640.302 | 1647.486 | 1654.689 | 45     |
| 46     | 1661.906 | 1669.140 | 1676.389 | 1683.654 | 1690.935 | 1698.231 | 1705.543 | 1712.871 | 1720.214 | 1727.574 | 46     |
| 47     | 1734.949 | 1742.339 | 1749.746 | 1757.168 | 1764.605 | 1772.059 | 1779.528 | 1787.013 | 1794.513 | 1802.030 | 47     |
| 48     | 1809.562 | 1817.109 | 1824.673 | 1832.252 | 1839.847 | 1847.457 | 1855.083 | 1862.725 | 1870.383 | 1878.056 | 48     |
| 49     | 1885.745 | 1893.450 | 1901.171 | 1908.907 | 1916.659 | 1924.426 | 1932.210 | 1940.009 | 1947.823 | 1955.654 | 49     |
| 50     | 1963.500 | 1971.362 | 1979.239 | 1987.133 | 1995.042 | 2002.966 | 2010.907 | 2018.863 | 2026.835 | 2034.877 | 50     |
| 51     | 2042.825 | 2050.844 | 2058.878 | 2066.929 | 2074.995 | 2083.077 | 2091.175 | 2099.288 | 2107.417 | 2115.561 | 51     |
| 52     | 2123.722 | 2131.898 | 2140.089 | 2148.297 | 2156.520 | 2164.759 | 2173.013 | 2181.284 | 2189.570 | 2197.871 | 52     |
| 53     | 2206.189 | 2214.522 | 2222.870 | 2231.235 | 2239.615 | 2248.011 | 2256.423 | 2264.870 | 2273.293 | 2281.752 | 53     |
| 54     | 2290.226 | 2298.717 | 2307.222 | 2315.744 | 2324.281 | 2332.834 | 2341.403 | 2349.987 | 2358.588 | 2367.203 | 54     |
| 55     | 2375.835 | 2384.482 | 2393.145 | 2401.824 | 2410.518 | 2419.228 | 2427.954 | 2436.696 | 2445.453 | 2454.226 | 55     |
| 56     | 2463.014 | 2471.819 | 2480.639 | 2489.475 | 2498.326 | 2507.193 | 2516.076 | 2524.974 | 2533.889 | 2542.819 | 56     |
| 57     | 2551.765 | 2560.726 | 2569.703 | 2578.696 | 2587.705 | 2596.729 | 2605.769 | 2614.824 | 2623.896 | 2632.983 | 57     |
| 58     | 2642.086 | 2651.205 | 2660.338 | 2669.488 | 2678.654 | 2687.835 | 2697.032 | 2706.245 | 2715.473 | 2724.718 | 58     |
| 59     | 2733.977 | 2743.253 | 2752.544 | 2761.851 | 2771.174 | 2780.512 | 2789.866 | 2799.236 | 2808.622 | 2818.023 | 59     |
| Diamr. | Areas    |          |          |          |          |          |          |          |          |          | Diamr. |
|        | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       |        |

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (continued).

| Diamr. | Areas    |          |          |          |          |          |          |          |          |          | Areas |          |          |          |          |          |          |          |          |          | Diamr. |
|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------|
|        | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       |       |          |          |          |          |          |          |          |          |          |        |
| 60     | 2827.440 | 2836.873 | 2846.321 | 2855.785 | 2865.265 | 2874.760 | 2884.262 | 2893.798 | 2903.341 | 2912.899 | 60    | 2912.899 | 2903.341 | 2893.798 | 2884.262 | 2874.760 | 2865.265 | 2855.785 | 2846.321 | 2836.873 | 60     |
| 61     | 2922.473 | 2932.063 | 2941.669 | 2951.290 | 2960.927 | 2970.579 | 2980.247 | 2989.931 | 2999.630 | 3009.346 | 61    | 3009.346 | 2999.630 | 2989.931 | 2980.247 | 2970.579 | 2960.927 | 2951.290 | 2941.669 | 2932.063 | 61     |
| 62     | 3019.078 | 3028.824 | 3038.587 | 3048.365 | 3058.159 | 3067.969 | 3077.794 | 3087.634 | 3097.492 | 3107.364 | 62    | 3107.364 | 3097.492 | 3087.634 | 3077.794 | 3067.969 | 3058.159 | 3048.365 | 3038.587 | 3028.824 | 62     |
| 63     | 3117.253 | 3127.156 | 3137.076 | 3147.011 | 3156.966 | 3166.929 | 3176.912 | 3186.910 | 3196.924 | 3206.953 | 63    | 3206.953 | 3196.924 | 3186.910 | 3176.912 | 3166.929 | 3156.966 | 3147.011 | 3137.076 | 3127.156 | 63     |
| 64     | 3216.998 | 3227.059 | 3237.136 | 3247.228 | 3257.337 | 3267.460 | 3277.600 | 3287.755 | 3297.926 | 3308.113 | 64    | 3308.113 | 3297.926 | 3287.755 | 3277.600 | 3267.460 | 3257.337 | 3247.228 | 3237.136 | 3227.059 | 64     |
| 65     | 3318.315 | 3328.534 | 3338.767 | 3349.016 | 3359.281 | 3369.562 | 3379.859 | 3390.171 | 3400.499 | 3410.843 | 65    | 3410.843 | 3400.499 | 3390.171 | 3379.859 | 3369.562 | 3359.281 | 3349.016 | 3338.767 | 3328.534 | 65     |
| 66     | 3421.202 | 3431.578 | 3441.963 | 3452.375 | 3462.797 | 3473.235 | 3483.689 | 3494.164 | 3504.643 | 3515.143 | 66    | 3515.143 | 3504.643 | 3494.164 | 3483.689 | 3473.235 | 3462.797 | 3452.375 | 3441.963 | 3431.578 | 66     |
| 67     | 3525.661 | 3536.193 | 3546.741 | 3557.304 | 3567.884 | 3578.479 | 3589.090 | 3599.716 | 3610.358 | 3621.016 | 67    | 3621.016 | 3610.358 | 3599.716 | 3589.090 | 3578.479 | 3567.884 | 3557.304 | 3546.741 | 3536.193 | 67     |
| 68     | 3631.690 | 3642.379 | 3653.084 | 3663.804 | 3674.541 | 3685.293 | 3696.066 | 3706.845 | 3717.644 | 3728.459 | 68    | 3728.459 | 3717.644 | 3706.845 | 3696.066 | 3685.293 | 3674.541 | 3663.804 | 3653.084 | 3642.379 | 68     |
| 69     | 3739.289 | 3750.136 | 3760.998 | 3771.876 | 3782.769 | 3793.678 | 3804.603 | 3815.544 | 3826.500 | 3837.472 | 69    | 3837.472 | 3826.500 | 3815.544 | 3804.603 | 3793.678 | 3782.769 | 3771.876 | 3760.998 | 3750.136 | 69     |
| 70     | 3848.460 | 3859.495 | 3870.483 | 3881.517 | 3892.568 | 3903.634 | 3914.716 | 3925.814 | 3936.927 | 3948.057 | 70    | 3948.057 | 3936.927 | 3925.814 | 3914.716 | 3903.634 | 3892.568 | 3881.517 | 3870.483 | 3859.495 | 70     |
| 71     | 3959.201 | 3970.362 | 3981.538 | 3992.730 | 4003.937 | 4015.161 | 4026.400 | 4037.655 | 4048.925 | 4060.212 | 71    | 4060.212 | 4048.925 | 4037.655 | 4026.400 | 4015.161 | 4003.937 | 3992.730 | 3981.538 | 3970.362 | 71     |
| 72     | 4071.514 | 4082.833 | 4094.163 | 4105.513 | 4116.879 | 4128.259 | 4139.652 | 4151.067 | 4162.494 | 4173.938 | 72    | 4173.938 | 4162.494 | 4151.067 | 4139.652 | 4128.259 | 4116.879 | 4105.513 | 4094.163 | 4082.833 | 72     |
| 73     | 4185.397 | 4196.871 | 4208.361 | 4219.868 | 4231.390 | 4242.927 | 4254.480 | 4266.049 | 4277.634 | 4289.234 | 73    | 4289.234 | 4277.634 | 4266.049 | 4254.480 | 4242.927 | 4231.390 | 4219.868 | 4208.361 | 4196.871 | 73     |
| 74     | 4300.850 | 4312.482 | 4324.130 | 4335.793 | 4347.472 | 4359.166 | 4370.877 | 4382.603 | 4394.345 | 4406.102 | 74    | 4406.102 | 4394.345 | 4382.603 | 4370.877 | 4359.166 | 4347.472 | 4335.793 | 4324.130 | 4312.482 | 74     |
| 75     | 4417.875 | 4429.664 | 4441.468 | 4453.289 | 4465.125 | 4476.976 | 4488.844 | 4500.727 | 4512.626 | 4524.540 | 75    | 4524.540 | 4512.626 | 4500.727 | 4488.844 | 4476.976 | 4465.125 | 4453.289 | 4441.468 | 4429.664 | 75     |
| 76     | 4536.470 | 4548.416 | 4560.379 | 4572.355 | 4584.358 | 4596.357 | 4608.382 | 4620.422 | 4632.478 | 4644.549 | 76    | 4644.549 | 4632.478 | 4620.422 | 4608.382 | 4596.357 | 4584.358 | 4572.355 | 4560.379 | 4548.416 | 76     |
| 77     | 4656.637 | 4668.740 | 4680.858 | 4692.993 | 4705.143 | 4717.309 | 4729.490 | 4741.688 | 4753.961 | 4766.129 | 77    | 4766.129 | 4753.961 | 4741.688 | 4729.490 | 4717.309 | 4705.143 | 4692.993 | 4680.858 | 4668.740 | 77     |
| 78     | 4778.374 | 4790.634 | 4802.909 | 4815.201 | 4827.508 | 4839.831 | 4852.170 | 4864.524 | 4876.897 | 4889.280 | 78    | 4889.280 | 4876.897 | 4864.524 | 4852.170 | 4839.831 | 4827.508 | 4815.201 | 4802.909 | 4790.634 | 78     |
| 79     | 4901.681 | 4914.099 | 4926.531 | 4938.982 | 4951.444 | 4963.924 | 4976.484 | 4988.931 | 5001.459 | 5014.001 | 79    | 5014.001 | 5001.459 | 4988.931 | 4976.484 | 4963.924 | 4951.444 | 4938.982 | 4926.531 | 4914.099 | 79     |

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (concluded).

| Diamr. | Areas    |          |          |          |          |          |          |          |          |          | Diamr. |
|--------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------|
|        | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       |        |
| 80     | 5026.560 | 5039.134 | 5051.724 | 5064.330 | 5076.955 | 5089.588 | 5102.241 | 5114.910 | 5127.594 | 5140.294 | 80     |
| 81     | 5153.009 | 5165.741 | 5178.488 | 5191.251 | 5204.029 | 5216.823 | 5229.633 | 5242.459 | 5255.300 | 5268.157 | 81     |
| 82     | 5281.030 | 5293.918 | 5306.822 | 5319.744 | 5332.678 | 5345.629 | 5358.596 | 5371.598 | 5384.576 | 5397.591 | 82     |
| 83     | 5410.621 | 5423.666 | 5436.727 | 5449.804 | 5462.897 | 5476.005 | 5489.129 | 5502.269 | 5515.424 | 5528.596 | 83     |
| 84     | 5541.702 | 5554.985 | 5568.203 | 5581.437 | 5594.687 | 5607.952 | 5621.233 | 5634.568 | 5647.843 | 5661.171 | 84     |
| 85     | 5674.515 | 5687.875 | 5701.250 | 5714.641 | 5728.048 | 5741.470 | 5754.909 | 5768.362 | 5781.832 | 5795.317 | 85     |
| 86     | 5808.818 | 5822.335 | 5835.868 | 5849.416 | 5862.980 | 5876.559 | 5890.154 | 5903.765 | 5917.392 | 5931.034 | 86     |
| 87     | 5944.693 | 5958.364 | 5972.056 | 5985.769 | 5999.482 | 6013.219 | 6026.971 | 6040.739 | 6054.515 | 6068.322 | 87     |
| 88     | 6082.138 | 6095.968 | 6109.815 | 6123.677 | 6137.555 | 6151.449 | 6165.359 | 6179.284 | 6193.225 | 6207.181 | 88     |
| 89     | 6221.153 | 6235.141 | 6249.145 | 6263.164 | 6277.200 | 6291.204 | 6305.317 | 6319.399 | 6333.497 | 6347.681 | 89     |
| 90     | 6361.740 | 6375.885 | 6390.046 | 6404.222 | 6418.414 | 6432.622 | 6446.844 | 6461.085 | 6475.340 | 6489.611 | 90     |
| 91     | 6503.897 | 6518.200 | 6532.517 | 6546.891 | 6561.208 | 6575.565 | 6589.946 | 6604.322 | 6618.754 | 6633.182 | 91     |
| 92     | 6647.626 | 6662.085 | 6676.560 | 6691.016 | 6705.557 | 6720.079 | 6734.617 | 6749.170 | 6763.739 | 6778.324 | 92     |
| 93     | 6792.925 | 6807.541 | 6822.173 | 6836.821 | 6851.484 | 6866.163 | 6880.858 | 6895.569 | 6910.295 | 6925.037 | 93     |
| 94     | 6939.794 | 6954.568 | 6969.357 | 6984.161 | 6998.982 | 7013.818 | 7028.670 | 7043.503 | 7058.418 | 7073.320 | 94     |
| 95     | 7088.235 | 7103.165 | 7118.112 | 7133.073 | 7148.051 | 7163.044 | 7178.053 | 7193.078 | 7208.118 | 7223.175 | 95     |
| 96     | 7238.246 | 7253.384 | 7268.437 | 7283.556 | 7298.691 | 7313.841 | 7329.007 | 7344.189 | 7359.386 | 7374.600 | 96     |
| 97     | 7389.829 | 7405.073 | 7420.334 | 7435.610 | 7450.901 | 7466.209 | 7481.532 | 7496.871 | 7512.225 | 7527.596 | 97     |
| 98     | 7542.982 | 7558.383 | 7573.801 | 7589.234 | 7604.683 | 7620.147 | 7635.627 | 7651.193 | 7666.635 | 7682.162 | 98     |
| 99     | 7697.705 | 7713.264 | 7728.839 | 7744.429 | 7760.035 | 7775.656 | 7791.294 | 7806.947 | 7822.615 | 7838.300 | 99     |
| Diamr. | Areas    |          |          |          |          |          |          |          |          |          | Diamr. |
|        | .0       | .1       | .2       | .3       | .4       | .5       | .6       | .7       | .8       | .9       |        |

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 12THS.

| Diameter | Circumferences |                |                |                |                |                |                |                |                |                |                 |                 | Diameter |
|----------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|----------|
|          | 0              | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{3}{12}$ | $\frac{4}{12}$ | $\frac{5}{12}$ | $\frac{6}{12}$ | $\frac{7}{12}$ | $\frac{8}{12}$ | $\frac{9}{12}$ | $\frac{10}{12}$ | $\frac{11}{12}$ |          |
| 0        | 0.0000         | 26180          | 52360          | 78540          | 1.0472         | 1.3090         | 1.5709         | 1.8326         | 2.0944         | 2.3562         | 2.6180          | 2.8798          | 0        |
| 1        | 3.1416         | 3.4034         | 3.6652         | 3.9270         | 4.1888         | 4.4506         | 4.7124         | 4.9742         | 5.2360         | 5.4978         | 5.7596          | 6.0214          | 1        |
| 2        | 6.2832         | 6.5450         | 6.8068         | 7.0686         | 7.3304         | 7.5922         | 7.8540         | 8.1158         | 8.3776         | 8.6394         | 8.9012          | 9.1630          | 2        |
| 3        | 9.4248         | 9.6866         | 9.9484         | 10.2102        | 10.4720        | 10.7338        | 10.9956        | 11.2574        | 11.5192        | 11.7810        | 12.0428         | 12.3046         | 3        |
| 4        | 12.5664        | 12.8282        | 13.0900        | 13.3518        | 13.6136        | 13.8754        | 14.1372        | 14.3990        | 14.6608        | 14.9226        | 15.1844         | 15.4462         | 4        |
| 5        | 15.7080        | 15.9698        | 16.2316        | 16.4934        | 16.7552        | 17.0170        | 17.2788        | 17.5406        | 17.8024        | 18.0642        | 18.3260         | 18.5878         | 5        |
| 6        | 18.8496        | 19.1114        | 19.3732        | 19.6350        | 19.8968        | 20.1586        | 20.4204        | 20.6822        | 20.9440        | 21.2058        | 21.4676         | 21.7294         | 6        |
| 7        | 21.9912        | 22.2530        | 22.5148        | 22.7766        | 23.0384        | 23.3002        | 23.5620        | 23.8238        | 24.0856        | 24.3474        | 24.6092         | 24.8710         | 7        |
| 8        | 25.1328        | 25.3946        | 25.6564        | 25.9182        | 26.1800        | 26.4418        | 26.7036        | 26.9654        | 27.2272        | 27.4890        | 27.7508         | 28.0126         | 8        |
| 9        | 28.2744        | 28.5362        | 28.7980        | 29.0598        | 29.3216        | 29.5834        | 29.8452        | 30.1070        | 30.3688        | 30.6306        | 30.8924         | 31.1542         | 9        |
| 10       | 31.4160        | 31.6778        | 31.9396        | 32.2014        | 32.4632        | 32.7250        | 32.9868        | 32.2486        | 33.5104        | 33.7722        | 34.0340         | 34.2958         | 10       |
| 11       | 34.5576        | 34.8194        | 35.0812        | 35.3430        | 35.6048        | 35.8666        | 36.1284        | 36.3902        | 36.6520        | 36.9138        | 37.1756         | 37.4374         | 11       |
| 12       | 37.6992        | 37.9610        | 38.2228        | 38.4846        | 38.7464        | 39.0082        | 39.2700        | 39.5318        | 39.7936        | 40.0554        | 40.3172         | 40.5790         | 12       |
| 13       | 40.8408        | 41.1026        | 41.3644        | 41.6262        | 41.8880        | 42.1498        | 42.4116        | 42.6734        | 42.9352        | 43.1970        | 43.4588         | 43.7206         | 13       |
| 14       | 43.9824        | 44.2442        | 44.5060        | 44.7678        | 45.0296        | 45.2914        | 45.5532        | 45.8150        | 46.0768        | 46.3386        | 46.6004         | 46.8622         | 14       |
| 15       | 47.1240        | 47.3858        | 47.6476        | 47.9094        | 48.1712        | 48.4330        | 48.6948        | 48.9566        | 49.2184        | 49.4802        | 49.7420         | 50.0038         | 15       |
| 16       | 50.2656        | 50.5274        | 50.7892        | 51.0510        | 51.3128        | 51.5746        | 51.8364        | 52.0982        | 52.3600        | 52.6218        | 52.8836         | 53.1454         | 16       |
| 17       | 53.4072        | 53.6690        | 53.9308        | 54.1926        | 54.4544        | 54.7162        | 54.9780        | 55.2398        | 55.5016        | 55.7634        | 56.0252         | 56.2870         | 17       |
| 18       | 56.5488        | 56.8106        | 57.0724        | 57.3342        | 57.5960        | 57.8578        | 58.1196        | 58.3814        | 58.6432        | 58.9050        | 59.1668         | 59.4286         | 18       |
| 19       | 59.6904        | 59.9522        | 60.2140        | 60.4758        | 60.7376        | 60.9994        | 61.2612        | 61.5230        | 61.7848        | 62.0466        | 62.3084         | 62.5702         | 19       |
| Diameter | Circumferences |                |                |                |                |                |                |                |                |                |                 |                 | Diameter |
|          | 0              | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{3}{12}$ | $\frac{4}{12}$ | $\frac{5}{12}$ | $\frac{6}{12}$ | $\frac{7}{12}$ | $\frac{8}{12}$ | $\frac{9}{12}$ | $\frac{10}{12}$ | $\frac{11}{12}$ |          |

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 12THS (concluded).

| Diameter. | Circumferences. |                |                |                |                |                |                |                |                |                |                 |                 | Diameter. |
|-----------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------|
|           | 0               | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{3}{12}$ | $\frac{4}{12}$ | $\frac{5}{12}$ | $\frac{6}{12}$ | $\frac{7}{12}$ | $\frac{8}{12}$ | $\frac{9}{12}$ | $\frac{10}{12}$ | $\frac{11}{12}$ |           |
| 20        | 62.8320         | 63.0938        | 63.3556        | 63.6174        | 63.8792        | 64.1410        | 64.4028        | 64.6646        | 64.9264        | 65.1882        | 65.4500         | 65.7118         | 20        |
| 21        | 65.9796         | 66.2354        | 66.4912        | 66.7470        | 67.0028        | 67.2586        | 67.5144        | 67.7702        | 68.0260        | 68.2818        | 68.5376         | 68.7934         | 21        |
| 22        | 69.1152         | 69.3770        | 69.6388        | 69.9006        | 70.1624        | 70.4242        | 70.6860        | 70.9478        | 71.2096        | 71.4714        | 71.7332         | 71.9950         | 22        |
| 23        | 72.2568         | 72.5186        | 72.7804        | 73.0422        | 73.3040        | 73.5658        | 73.8276        | 74.0894        | 74.3512        | 74.6130        | 74.8748         | 75.1366         | 23        |
| 24        | 75.3984         | 75.6602        | 75.9220        | 76.1838        | 76.4456        | 76.7074        | 76.9692        | 77.2310        | 77.4928        | 77.7546        | 78.0164         | 78.2782         | 24        |
| 25        | 78.5400         | 78.8018        | 79.0636        | 79.3254        | 79.5872        | 79.8490        | 80.1108        | 80.3726        | 80.6344        | 80.8962        | 81.1580         | 81.4198         | 25        |
| 26        | 81.6816         | 81.9434        | 82.2052        | 82.4670        | 82.7288        | 82.9906        | 83.2524        | 83.5142        | 83.7760        | 84.0378        | 84.2996         | 84.5614         | 26        |
| 27        | 84.8232         | 85.0850        | 85.3468        | 85.6086        | 85.8704        | 86.1322        | 86.3940        | 86.6558        | 86.9176        | 87.1794        | 87.4412         | 87.7030         | 27        |
| 28        | 87.9648         | 88.2266        | 88.4884        | 88.7502        | 89.0120        | 89.2738        | 89.5356        | 89.7974        | 90.0592        | 90.3210        | 90.5828         | 90.8446         | 28        |
| 29        | 91.1064         | 91.3682        | 91.6300        | 91.8918        | 92.1536        | 92.4154        | 92.6772        | 92.9390        | 93.2008        | 93.4626        | 93.7244         | 93.9862         | 29        |
| 30        | 94.2480         | 94.5098        | 94.7716        | 95.0334        | 95.2952        | 95.5570        | 95.8188        | 96.0806        | 96.3424        | 96.6042        | 96.8660         | 97.1278         | 30        |
| 31        | 97.3896         | 97.6514        | 97.9132        | 98.1750        | 98.4368        | 98.6986        | 98.9604        | 99.2222        | 99.4840        | 99.7458        | 100.0076        | 100.2694        | 31        |
| 32        | 100.531         | 100.793        | 101.055        | 101.317        | 101.578        | 101.840        | 102.102        | 102.364        | 102.626        | 102.887        | 103.149         | 103.411         | 32        |
| 33        | 103.673         | 103.935        | 104.196        | 104.458        | 104.720        | 104.982        | 105.244        | 105.505        | 105.767        | 106.029        | 106.291         | 106.553         | 33        |
| 34        | 106.814         | 107.076        | 107.338        | 107.600        | 107.862        | 108.123        | 108.385        | 108.647        | 108.909        | 109.171        | 109.432         | 109.694         | 34        |
| 35        | 109.956         | 110.218        | 110.480        | 110.741        | 111.003        | 111.265        | 111.527        | 111.789        | 112.050        | 112.312        | 112.574         | 112.836         | 35        |
| 36        | 113.098         | 113.359        | 113.621        | 113.883        | 114.145        | 114.407        | 114.668        | 114.930        | 115.192        | 115.454        | 115.716         | 115.977         | 36        |
| 37        | 116.239         | 116.501        | 116.763        | 117.025        | 117.286        | 117.548        | 117.810        | 118.072        | 118.334        | 118.596        | 118.857         | 119.119         | 37        |
| 38        | 119.381         | 119.643        | 119.904        | 120.166        | 120.428        | 120.690        | 120.952        | 121.213        | 121.475        | 121.737        | 121.999         | 122.261         | 38        |
| 39        | 122.522         | 122.784        | 123.046        | 123.308        | 123.570        | 123.831        | 124.093        | 124.355        | 124.617        | 124.879        | 125.140         | 125.402         | 39        |
| Diameter. | Circumferences. |                |                |                |                |                |                |                |                |                |                 |                 | Diameter. |
|           | 0               | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{3}{12}$ | $\frac{4}{12}$ | $\frac{5}{12}$ | $\frac{6}{12}$ | $\frac{7}{12}$ | $\frac{8}{12}$ | $\frac{9}{12}$ | $\frac{10}{12}$ | $\frac{11}{12}$ |           |

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 12THS.

| Diamr. | Areas   |                |                |                |                |                |                |                |                |                |                 |                 | Diamr. |
|--------|---------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|--------|
|        | 0       | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{3}{12}$ | $\frac{4}{12}$ | $\frac{5}{12}$ | $\frac{6}{12}$ | $\frac{7}{12}$ | $\frac{8}{12}$ | $\frac{9}{12}$ | $\frac{10}{12}$ | $\frac{11}{12}$ |        |
| 0      | ·0000   | ·0055          | ·0218          | ·0491          | ·0873          | ·1364          | ·1963          | ·2673          | ·3491          | ·4418          | ·5454           | ·6600           | 0      |
| 1      | ·7854   | ·9218          | 1·0690         | 1·2272         | 1·3963         | 1·5763         | 1·7671         | 1·9689         | 2·1817         | 2·4053         | 2·6398          | 2·8852          | 1      |
| 2      | 3·1416  | 3·4088         | 3·6870         | 3·9761         | 4·2761         | 4·5869         | 4·9087         | 5·2414         | 5·5851         | 5·9396         | 6·3050          | 6·6813          | 2      |
| 3      | 7·0686  | 7·4667         | 7·8758         | 8·2958         | 8·7266         | 9·1684         | 9·6211         | 10·0847        | 10·5592        | 11·0447        | 11·5410         | 12·0482         | 3      |
| 4      | 12·5664 | 13·0954        | 13·6354        | 14·1863        | 14·7480        | 15·3207        | 15·9043        | 16·4988        | 17·1042        | 17·7205        | 18·3478         | 18·9859         | 4      |
| 5      | 19·6350 | 20·2949        | 20·9658        | 21·6475        | 22·3402        | 23·0438        | 23·7583        | 24·4837        | 25·2200        | 25·9672        | 26·7254         | 27·4944         | 5      |
| 6      | 28·2743 | 29·0652        | 29·8669        | 30·6796        | 31·5032        | 32·3377        | 33·1831        | 34·0394        | 34·9066        | 35·7847        | 36·6737         | 37·5737         | 6      |
| 7      | 38·4846 | 39·4063        | 40·3389        | 41·2825        | 42·2370        | 43·2024        | 44·1786        | 45·1658        | 46·1640        | 47·1730        | 48·1929         | 49·2237         | 7      |
| 8      | 50·2655 | 51·3181        | 52·3817        | 53·4562        | 54·5415        | 55·6378        | 56·7450        | 57·8631        | 58·9921        | 60·1320        | 61·2829         | 62·4446         | 8      |
| 9      | 63·6173 | 64·8008        | 65·9953        | 67·2006        | 68·4169        | 69·6441        | 70·8822        | 72·1312        | 73·3911        | 74·6619        | 75·9436         | 77·2363         | 9      |
| 10     | 78·5398 | 79·8543        | 81·1796        | 82·5159        | 83·8631        | 85·2212        | 86·5901        | 87·9700        | 89·3609        | 90·7626        | 92·1752         | 93·5987         | 10     |
| 11     | 95·0332 | 96·4785        | 97·9348        | 99·4020        | 100·880        | 102·369        | 103·869        | 105·380        | 106·901        | 108·434        | 109·978         | 111·532         | 11     |
| 12     | 113·097 | 114·674        | 116·261        | 117·859        | 119·468        | 121·088        | 122·719        | 124·360        | 126·013        | 127·676        | 129·351         | 131·036         | 12     |
| 13     | 132·732 | 134·439        | 136·158        | 137·887        | 139·626        | 141·377        | 143·139        | 144·911        | 146·695        | 148·489        | 150·295         | 152·111         | 13     |
| 14     | 153·938 | 155·776        | 157·625        | 159·485        | 161·356        | 163·237        | 165·130        | 167·034        | 168·948        | 170·873        | 172·809         | 174·757         | 14     |
| 15     | 176·715 | 178·684        | 180·663        | 182·654        | 184·656        | 186·663        | 188·692        | 190·726        | 192·772        | 194·828        | 196·895         | 198·973         | 15     |
| 16     | 201·062 | 203·162        | 205·273        | 207·394        | 209·527        | 211·670        | 213·825        | 215·990        | 218·166        | 220·353        | 222·551         | 224·760         | 16     |
| 17     | 226·980 | 229·211        | 231·453        | 233·705        | 235·969        | 238·243        | 240·528        | 242·824        | 245·132        | 247·450        | 249·778         | 252·118         | 17     |
| 18     | 254·469 | 256·831        | 259·203        | 261·587        | 263·981        | 266·386        | 268·803        | 271·230        | 273·668        | 276·117        | 278·576         | 281·047         | 18     |
| 19     | 283·529 | 286·021        | 288·525        | 291·039        | 293·564        | 296·111        | 298·648        | 301·206        | 303·775        | 306·354        | 308·945         | 311·547         | 19     |
| Diamr. | 0       | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{3}{12}$ | $\frac{4}{12}$ | $\frac{5}{12}$ | $\frac{6}{12}$ | $\frac{7}{12}$ | $\frac{8}{12}$ | $\frac{9}{12}$ | $\frac{10}{12}$ | $\frac{11}{12}$ | Diamr. |

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 12THS (concluded).

| Diameter. | Areas   |                |                |                |                |                |                |                |                |                |                 |                 | Diameter. |
|-----------|---------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------|
|           | 0       | $\frac{1}{12}$ | $\frac{2}{12}$ | $\frac{3}{12}$ | $\frac{4}{12}$ | $\frac{5}{12}$ | $\frac{6}{12}$ | $\frac{7}{12}$ | $\frac{8}{12}$ | $\frac{9}{12}$ | $\frac{10}{12}$ | $\frac{11}{12}$ |           |
| 20        | 314 159 | 316 783        | 319 417        | 322 062        | 324 719        | 327 386        | 330 064        | 332 753        | 335 452        | 338 163        | 340 885         | 343 617         | 20        |
| 21        | 316 361 | 319 115        | 321 880        | 324 656        | 327 443        | 330 241        | 333 050        | 335 870        | 338 701        | 341 542        | 344 395         | 347 258         | 21        |
| 22        | 318 013 | 320 818        | 323 634        | 326 461        | 329 300        | 332 149        | 335 009        | 337 880        | 340 761        | 343 652        | 346 553         | 349 464         | 22        |
| 23        | 319 676 | 322 522        | 325 380        | 328 249        | 331 129        | 334 019        | 336 920        | 339 831        | 342 752        | 345 683        | 348 624         | 351 575         | 23        |
| 24        | 321 352 | 324 240        | 327 140        | 330 051        | 332 972        | 335 903        | 338 844        | 341 795        | 344 756        | 347 727        | 350 708         | 353 699         | 24        |
| 25        | 323 040 | 325 970        | 328 911        | 331 862        | 334 823        | 337 794        | 340 775        | 343 766        | 346 767        | 349 778        | 352 799         | 355 820         | 25        |
| 26        | 324 740 | 327 701        | 330 672        | 333 653        | 336 644        | 339 645        | 342 656        | 345 677        | 348 698        | 351 729        | 354 760         | 357 791         | 26        |
| 27        | 326 452 | 329 433        | 332 424        | 335 425        | 338 436        | 341 447        | 344 458        | 347 469        | 350 480        | 353 491        | 356 502         | 359 513         | 27        |
| 28        | 328 176 | 331 177        | 334 188        | 337 200        | 340 211        | 343 222        | 346 233        | 349 244        | 352 255        | 355 266        | 358 277         | 361 288         | 28        |
| 29        | 329 912 | 332 933        | 335 964        | 338 995        | 342 026        | 345 057        | 348 088        | 351 119        | 354 150        | 357 181        | 360 212         | 363 243         | 29        |
| 30        | 331 659 | 334 690        | 337 721        | 340 752        | 343 783        | 346 814        | 349 845        | 352 876        | 355 907        | 358 938        | 361 969         | 364 999         | 30        |
| 31        | 333 417 | 336 458        | 339 500        | 342 541        | 345 582        | 348 623        | 351 664        | 354 705        | 357 746        | 360 787        | 363 828         | 366 869         | 31        |
| 32        | 335 185 | 338 236        | 341 287        | 344 338        | 347 389        | 350 440        | 353 491        | 356 542        | 359 593        | 362 644        | 365 695         | 368 746         | 32        |
| 33        | 336 963 | 340 024        | 343 085        | 346 146        | 349 207        | 352 268        | 355 329        | 358 390        | 361 451        | 364 512        | 367 573         | 370 634         | 33        |
| 34        | 338 751 | 341 822        | 344 893        | 347 964        | 351 035        | 354 106        | 357 177        | 360 248        | 363 319        | 366 390        | 369 461         | 372 532         | 34        |
| 35        | 340 549 | 343 630        | 346 711        | 349 792        | 352 873        | 355 954        | 359 035        | 362 116        | 365 197        | 368 278        | 371 359         | 374 439         | 35        |
| 36        | 342 357 | 345 448        | 348 539        | 351 630        | 354 721        | 357 812        | 360 903        | 363 994        | 367 085        | 370 176        | 373 267         | 376 358         | 36        |
| 37        | 344 175 | 347 276        | 350 377        | 353 478        | 356 579        | 359 680        | 362 781        | 365 882        | 368 983        | 372 084        | 375 185         | 378 286         | 37        |
| 38        | 345 993 | 349 104        | 352 215        | 355 326        | 358 437        | 361 548        | 364 659        | 367 770        | 370 881        | 373 992        | 377 103         | 380 214         | 38        |
| 39        | 347 821 | 350 932        | 354 043        | 357 154        | 360 265        | 363 376        | 366 487        | 369 598        | 372 709        | 375 820        | 378 931         | 382 042         | 39        |

TABLE OF THE AREAS OF THE SEGMENTS OF A CIRCLE,  
THE DIAMETER BEING UNITY.

*To find the area of the segment of any circle from the following tables.*

RULE.—Divide the height of the segment by the diameter, take out the corresponding tabular area, which multiply by the square of the diameter for the result.

| $\frac{H}{D}$ | Area    | $\frac{H}{D}$ | Area    | $\frac{H}{D}$ | Area    | $\frac{H}{D}$ | Area    |
|---------------|---------|---------------|---------|---------------|---------|---------------|---------|
| ·001          | ·000042 | ·038          | ·009763 | ·075          | ·026761 | ·112          | ·048262 |
| ·002          | ·000119 | ·039          | ·010148 | ·076          | ·027289 | ·113          | ·048894 |
| ·003          | ·000219 | ·040          | ·010537 | ·077          | ·027821 | ·114          | ·049528 |
| ·004          | ·000337 | ·041          | ·010931 | ·078          | ·028356 | ·115          | ·050165 |
| ·005          | ·000470 | ·042          | ·011330 | ·079          | ·028894 | ·116          | ·050804 |
| ·006          | ·000618 | ·043          | ·011734 | ·080          | ·029435 | ·117          | ·051446 |
| ·007          | ·000779 | ·044          | ·012142 | ·081          | ·029979 | ·118          | ·052090 |
| ·008          | ·000951 | ·045          | ·012554 | ·082          | ·030526 | ·119          | ·052736 |
| ·009          | ·001135 | ·046          | ·012971 | ·083          | ·031076 | ·120          | ·053385 |
| ·010          | ·001329 | ·047          | ·013392 | ·084          | ·031629 | ·121          | ·054036 |
| ·011          | ·001533 | ·048          | ·013818 | ·085          | ·032186 | ·122          | ·054689 |
| ·012          | ·001746 | ·049          | ·014247 | ·086          | ·032745 | ·123          | ·055345 |
| ·013          | ·001968 | ·050          | ·014681 | ·087          | ·033307 | ·124          | ·056003 |
| ·014          | ·002199 | ·051          | ·015119 | ·088          | ·033872 | ·125          | ·056663 |
| ·015          | ·002438 | ·052          | ·015561 | ·089          | ·034441 | ·126          | ·057326 |
| ·016          | ·002685 | ·053          | ·016007 | ·090          | ·035011 | ·127          | ·057991 |
| ·017          | ·002940 | ·054          | ·016457 | ·091          | ·035585 | ·128          | ·058658 |
| ·018          | ·003202 | ·055          | ·016911 | ·092          | ·036162 | ·129          | ·059327 |
| ·019          | ·003471 | ·056          | ·017369 | ·093          | ·036741 | ·130          | ·059999 |
| ·020          | ·003748 | ·057          | ·017831 | ·094          | ·037323 | ·131          | ·060672 |
| ·021          | ·004031 | ·058          | ·018296 | ·095          | ·037909 | ·132          | ·061348 |
| ·022          | ·004322 | ·059          | ·018766 | ·096          | ·038496 | ·133          | ·062026 |
| ·023          | ·004618 | ·060          | ·019239 | ·097          | ·039087 | ·134          | ·062707 |
| ·024          | ·004921 | ·061          | ·019716 | ·098          | ·039680 | ·135          | ·063389 |
| ·025          | ·005230 | ·062          | ·020196 | ·099          | ·040276 | ·136          | ·064074 |
| ·026          | ·005546 | ·063          | ·020680 | ·100          | ·040875 | ·137          | ·064760 |
| ·027          | ·005867 | ·064          | ·021168 | ·101          | ·041476 | ·138          | ·065449 |
| ·028          | ·006194 | ·065          | ·021659 | ·102          | ·042080 | ·139          | ·066140 |
| ·029          | ·006527 | ·066          | ·022154 | ·103          | ·042687 | ·140          | ·066833 |
| ·030          | ·006865 | ·067          | ·022652 | ·104          | ·043296 | ·141          | ·067528 |
| ·031          | ·007209 | ·068          | ·023154 | ·105          | ·043908 | ·142          | ·068225 |
| ·032          | ·007558 | ·069          | ·023659 | ·106          | ·044522 | ·143          | ·068924 |
| ·033          | ·007913 | ·070          | ·024168 | ·107          | ·045139 | ·144          | ·069625 |
| ·034          | ·008273 | ·071          | ·024680 | ·108          | ·045759 | ·145          | ·070328 |
| ·035          | ·008638 | ·072          | ·025195 | ·109          | ·046381 | ·146          | ·071033 |
| ·036          | ·009008 | ·073          | ·025714 | ·110          | ·047005 | ·147          | ·071741 |
| ·037          | ·009383 | ·074          | ·026236 | ·111          | ·047632 | ·148          | ·072450 |



TABLE OF THE AREAS OF THE SEGMENTS OF A CIRCLE,  
THE DIAMETER BEING UNITY (continued).

| $\frac{H}{D}$ | Area   | $\frac{H}{D}$ | Area   | $\frac{H}{D}$ | Area   | $\frac{H}{D}$ | Area   |
|---------------|--------|---------------|--------|---------------|--------|---------------|--------|
| 149           | 073161 | 193           | 106261 | 237           | 142387 | 281           | 180918 |
| 150           | 073874 | 194           | 107051 | 238           | 143288 | 282           | 181817 |
| 151           | 074589 | 195           | 107842 | 239           | 144091 | 283           | 182718 |
| 152           | 075306 | 196           | 108636 | 240           | 144944 | 284           | 183619 |
| 153           | 076026 | 197           | 109430 | 241           | 145799 | 285           | 184521 |
| 154           | 076747 | 198           | 110226 | 242           | 146655 | 286           | 185425 |
| 155           | 077469 | 199           | 111024 | 243           | 147512 | 287           | 186329 |
| 156           | 078194 | 200           | 111823 | 244           | 148371 | 288           | 187234 |
| 157           | 078921 | 201           | 112624 | 245           | 149230 | 289           | 188140 |
| 158           | 079649 | 202           | 113426 | 246           | 150091 | 290           | 189047 |
| 159           | 080380 | 203           | 114230 | 247           | 150953 | 291           | 189955 |
| 160           | 081112 | 204           | 115035 | 248           | 151816 | 292           | 190864 |
| 161           | 081846 | 205           | 115842 | 249           | 152680 | 293           | 191776 |
| 162           | 082582 | 206           | 116650 | 250           | 153546 | 294           | 192684 |
| 163           | 083320 | 207           | 117460 | 251           | 154412 | 295           | 193596 |
| 164           | 084059 | 208           | 118271 | 252           | 155280 | 296           | 194509 |
| 165           | 084801 | 209           | 119083 | 253           | 156149 | 297           | 195422 |
| 166           | 085544 | 210           | 119897 | 254           | 157019 | 298           | 196337 |
| 167           | 086289 | 211           | 120712 | 255           | 157890 | 299           | 197252 |
| 168           | 087036 | 212           | 121529 | 256           | 158762 | 300           | 198168 |
| 169           | 087783 | 213           | 122347 | 257           | 159636 | 301           | 199085 |
| 170           | 088535 | 214           | 123167 | 258           | 160510 | 302           | 200003 |
| 171           | 089287 | 215           | 123988 | 259           | 161386 | 303           | 200922 |
| 172           | 090041 | 216           | 124810 | 260           | 162263 | 304           | 201841 |
| 173           | 090797 | 217           | 125634 | 261           | 163140 | 305           | 202761 |
| 174           | 091554 | 218           | 126459 | 262           | 164019 | 306           | 203683 |
| 175           | 092313 | 219           | 127285 | 263           | 164899 | 307           | 204605 |
| 176           | 093074 | 220           | 128113 | 264           | 165780 | 308           | 205527 |
| 177           | 093836 | 221           | 128942 | 265           | 166663 | 309           | 206451 |
| 178           | 094601 | 222           | 129773 | 266           | 167546 | 310           | 207376 |
| 179           | 095366 | 223           | 130605 | 267           | 168430 | 311           | 208301 |
| 180           | 096134 | 224           | 131438 | 268           | 169315 | 312           | 209227 |
| 181           | 096903 | 225           | 132272 | 269           | 170202 | 313           | 210154 |
| 182           | 097674 | 226           | 133108 | 270           | 171089 | 314           | 211082 |
| 183           | 098447 | 227           | 133945 | 271           | 171978 | 315           | 212011 |
| 184           | 099221 | 228           | 134784 | 272           | 172867 | 316           | 212940 |
| 185           | 099997 | 229           | 135624 | 273           | 173758 | 317           | 213871 |
| 186           | 100774 | 230           | 136465 | 274           | 174649 | 318           | 214802 |
| 187           | 101553 | 231           | 137307 | 275           | 175542 | 319           | 215733 |
| 188           | 102334 | 232           | 138150 | 276           | 176435 | 320           | 216666 |
| 189           | 103116 | 233           | 138995 | 277           | 177330 | 321           | 217599 |
| 190           | 103900 | 234           | 139841 | 278           | 178225 | 322           | 218533 |
| 191           | 104685 | 235           | 140688 | 279           | 179122 | 323           | 219468 |
| 192           | 105472 | 236           | 141537 | 280           | 180019 | 324           | 220404 |

TABLE OF THE AREAS OF THE SEGMENTS OF A CIRCLE,  
THE DIAMETER BEING UNITY (concluded).

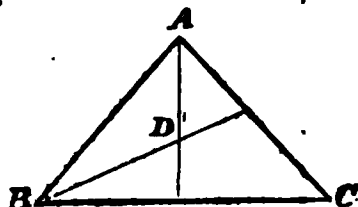
| $\frac{H}{D}$ | Area    | $\frac{H}{D}$ | Area    | $\frac{H}{D}$ | Area    | $\frac{H}{D}$ | Area    |
|---------------|---------|---------------|---------|---------------|---------|---------------|---------|
| .325          | .221340 | .369          | .268213 | .413          | .306140 | .457          | .349752 |
| .326          | .222277 | .370          | .264178 | .414          | .307125 | .458          | .350748 |
| .327          | .223215 | .371          | .265144 | .415          | .308110 | .459          | .351745 |
| .328          | .224154 | .372          | .266111 | .416          | .309095 | .460          | .352742 |
| .329          | .225093 | .373          | .267078 | .417          | .310081 | .461          | .353739 |
| .330          | .226033 | .374          | .268045 | .418          | .311068 | .462          | .354736 |
| .331          | .226974 | .375          | .269013 | .419          | .312054 | .463          | .355733 |
| .332          | .227915 | .376          | .269982 | .420          | .313041 | .464          | .356730 |
| .333          | .228856 | .377          | .270951 | .421          | .314029 | .465          | .357727 |
| .334          | .229801 | .378          | .271920 | .422          | .315016 | .466          | .358725 |
| .335          | .230745 | .379          | .272890 | .423          | .316004 | .467          | .359723 |
| .336          | .231689 | .380          | .273861 | .424          | .316992 | .468          | .360721 |
| .337          | .232634 | .381          | .274832 | .425          | .317981 | .469          | .361719 |
| .338          | .233580 | .382          | .275803 | .426          | .318970 | .470          | .362717 |
| .339          | .234526 | .383          | .276775 | .427          | .319959 | .471          | .363715 |
| .340          | .235473 | .384          | .277748 | .428          | .320948 | .472          | .364713 |
| .341          | .236421 | .385          | .278721 | .429          | .321938 | .473          | .365712 |
| .342          | .237369 | .386          | .279694 | .430          | .322928 | .474          | .366710 |
| .343          | .238318 | .387          | .280668 | .431          | .323918 | .475          | .367709 |
| .344          | .239268 | .388          | .281642 | .432          | .324909 | .476          | .368708 |
| .345          | .240218 | .389          | .282617 | .433          | .325900 | .477          | .369707 |
| .346          | .241169 | .390          | .283592 | .434          | .326892 | .478          | .370706 |
| .347          | .242121 | .391          | .284568 | .435          | .327883 | .479          | .371705 |
| .348          | .243074 | .392          | .285544 | .436          | .328874 | .480          | .372704 |
| .349          | .244028 | .393          | .286521 | .437          | .329865 | .481          | .373703 |
| .350          | .244980 | .394          | .287498 | .438          | .330858 | .482          | .374702 |
| .351          | .245934 | .395          | .288476 | .439          | .331850 | .483          | .375702 |
| .352          | .246889 | .396          | .289453 | .440          | .332843 | .484          | .376702 |
| .353          | .247845 | .397          | .290432 | .441          | .333836 | .485          | .377701 |
| .354          | .248801 | .398          | .291411 | .442          | .334829 | .486          | .378701 |
| .355          | .249757 | .399          | .292390 | .443          | .335822 | .487          | .379700 |
| .356          | .250715 | .400          | .293369 | .444          | .336816 | .488          | .380700 |
| .357          | .251673 | .401          | .294349 | .445          | .337810 | .489          | .381699 |
| .358          | .252631 | .402          | .295330 | .446          | .338804 | .490          | .382699 |
| .359          | .253590 | .403          | .296311 | .447          | .339798 | .491          | .383699 |
| .360          | .254550 | .404          | .297292 | .448          | .340793 | .492          | .384699 |
| .361          | .255510 | .405          | .298273 | .449          | .341787 | .493          | .385699 |
| .362          | .256471 | .406          | .299255 | .450          | .342782 | .494          | .386699 |
| .363          | .257433 | .407          | .300238 | .451          | .343777 | .495          | .387699 |
| .364          | .258395 | .408          | .301220 | .452          | .344772 | .496          | .388699 |
| .365          | .259357 | .409          | .302203 | .453          | .345768 | .497          | .389699 |
| .366          | .260320 | .410          | .303187 | .454          | .346764 | .498          | .390699 |
| .367          | .261284 | .411          | .304171 | .455          | .347759 | .499          | .391699 |
| .368          | .262248 | .412          | .305155 | .456          | .348755 | .500          | .392699 |

## CENTRES AND MOMENTS OF FIGURES.

TO FIND THE CENTRES OF A FEW SPECIAL FIGURES.

1. *Triangle.* (Fig. 104.)

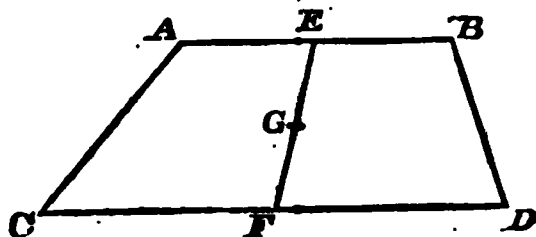
FIG. 104.



RULE.—From the middle points of any two sides draw lines to the opposite angle; the point of intersection D of these lines is the required centre.

2. *Trapezoid.* (Fig. 105.)

FIG. 105.

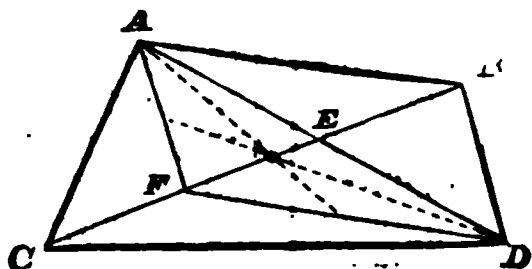


RULE.—Bisect AB in E and CD in F; join FE: then FG, the distance of the centre from CD along FE, is equal to

$$FG = \frac{EF}{2} \left\{ 1 - \frac{1}{3} \left( \frac{CD - AB}{CD + AB} \right) \right\}.$$

3. *Trapezium.* (Fig. 106.)

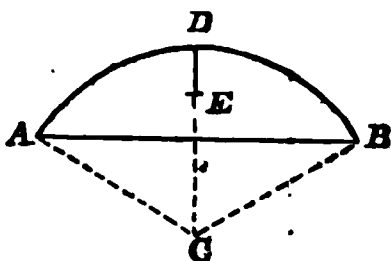
FIG. 106.



RULE.—Draw the diagonals AD and CB intersecting in E; along CB set off CF equal to EB, and join FA and FD: the centre of the triangle AFD will be the centre of the trapezium.

4. *Circular arc.* (Fig. 107.)

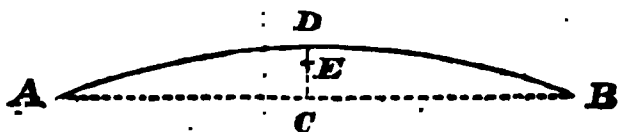
FIG. 107.



RULE.—Let AB be the circular arc and c the centre of the circle of which it is a part (to find c see p. 7); bisect the arc AB in D, and join DC and AB; multiply the radius CD by the chord AB, and divide by the length of the arc AB: lay off the quotient CE upon CD, then E is the centre required.

5. *Very flat curved line (approximate).* (Fig. 108.)

FIG. 108.



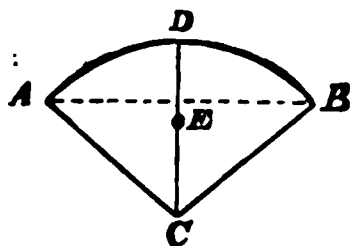
RULE.—Let ADB be the arc; draw the chord AB, and bisect it in C; draw CD perpendicular to AB; make CE equal to  $\frac{2}{3}$  of CD: then E

will be the centre required.

6. *Sector of a circle.* (Fig. 109.)

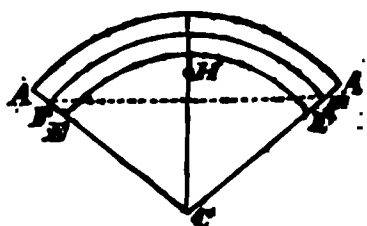
RULE.—Let  $ABC$  be the sector,  $C$  its centre; multiply the chord  $AB$  by  $\frac{3}{4}$  of the radius  $CA$ ; divide the product by the length of the arc: the quotient equals the distance  $CE$  set along the line  $CD$ ,  $D$  being at the bisection of the arc  $AB$ .

FIG. 109.

7. *Sector of a plane circular ring.* (Fig. 110.)

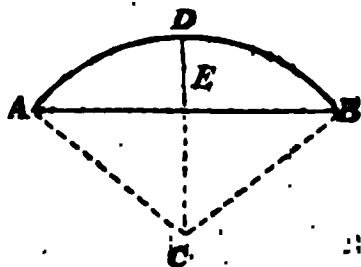
RULE.—Let  $CA$  be the outer and  $CE$  the inner radius of the ring; divide twice the difference of the cubes of the inner and outer radii by three times the difference of their squares; the quotient will be an intermediate radius  $CF$ , with which describe the arc  $FF$ , subtending the same angle with the sector: the centre  $H$  of the circular arc  $FF$ , found by Rule 4, will be the centre required.

FIG. 110.

8. *Circular segment.* (Fig. 111.)

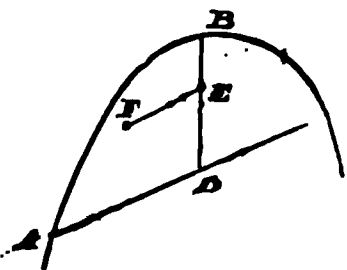
RULE.—Let  $C$  be the centre of the circle of which it is a part; bisect the arc  $AB$  in  $D$ , and join  $CD$ ; divide the cube of half the chord  $AB$  by three times the area of half the segment  $ADB$ : set off the quotient  $CE$  along  $CD$ , and  $E$  will be the centre required.

FIG. 111.

9. *Parabolic half-segment.* (Fig. 112.)

RULE.—Let  $ABD$  be a half-segment of a parabola,  $BD$  being part of a diameter parallel to the axis and  $AD$  an ordinate conjugate to that diameter—that is, parallel to a tangent at  $B$ . Make  $BE$  equal to  $\frac{2}{3}$   $BD$ , and draw  $EF$  parallel to  $AD$  and equal to  $\frac{2}{3}$   $AD$ . Then  $F$  will be the centre of the half-segment.

FIG. 112.

10. *Height of centre of semicircle from its base.*

RULE.—Multiply the diameter of the semicircle by 4, and divide the product by  $3\pi$ .

11. *Height of centre of parabola from its base.*

RULE.—Multiply its vertical height by 3, and divide the product by 5.

12. *Height of centre of elliptic segment from the lesser diameter of the ellipse of which it is a part.*

RULE.—Take the square of half the greater diameter of the ellipse, and divide the product by the square of half the lesser diameter; multiply that result by the cube of half the length of the base of the segment, and divide the result by three times its half-area.

*Ex.*: Let  $D$  = greater diameter of ellipse, and  $d$  = lesser diam.  
 $B$  = base of segment, and  $A$  = area of segment.  
 $H$  = height of centre from lesser diameter of ellipse.

$$H = \frac{\left(\frac{D}{2}\right)^2 \times \left(\frac{B}{2}\right)^2}{\left(\frac{d}{2}\right)^2 \times \frac{3A}{2}}$$

13. *Prism or cylinder with plane parallel ends.*

**RULE.**—Find the centres of the ends; a straight line joining them will be the axis of the prism or cylinder, and the middle point of that line will be the centre required.

14. *Cone or pyramid.*

**RULE.**—Find the centre of the base, from which draw a line to the summit; this will be the axis of the cone or pyramid, and the point at  $\frac{1}{4}$  from the base along that line will be the centre.

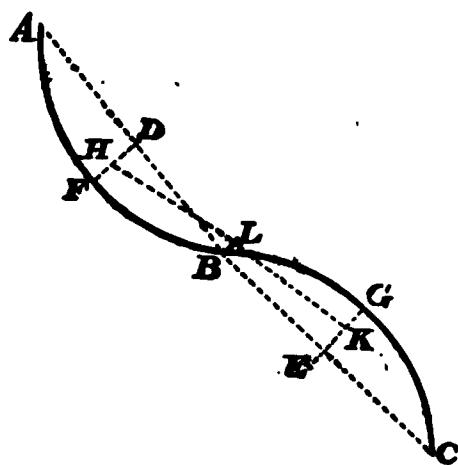
15. *Hemisphere or hemi-ellipsoid.*

**RULE.**—The distance of the centre from the circular or elliptic base is  $\frac{3}{8}$  of the radius of the sphere, or of that semi-axis of the ellipsoid which is perpendicular to the base.

16. *Paraboloid.*

**RULE.**—The distance of its centre from the base along its axis is  $\frac{1}{3}$  of the height from the base.

FIG. 113.



17. *To find the centre of gravity of any continuous curved line.* (Fig. 113.)

*Ex.*: Let  $ABC$  be the given curve; bisect it at  $B$ ; join  $AB$  and  $BC$ , and bisect those chords at the points  $D$  and  $E$  respectively; set off  $FD$  perpendicular to  $AB$ , and  $EG$  perpendicular to  $BC$ ; make  $FH = \frac{2}{3}DF$  and  $GK = \frac{2}{3}GE$ , and join  $HK$ ; bisect  $HK$  at the point  $L$ , which will be a close approximation to the position of the centre of gravity of the curved line  $ABC$ .

## RULES FOR FINDING THE MOMENTS AND CENTRES OF FIGURES.

*The geometrical moment of a figure, whether a line, an area, or a solid, relatively to a given plane or axis is the product of the magnitude of that figure, into the perpendicular distance of its centre from the given plane or axis, and is equal to the sum of the moments of all its parts relatively to the same plane.*

The centre of an area is determined when its distance from two axes in the plane of the figure is known.

The centre of a figure of three dimensions is determined

when its distance, from three planes not parallel to one another is known.

1. *To find the moment of an irregular figure relatively to a given plane or axis.*

**RULE.**—Divide the figure into parts whose centres are known; multiply the magnitude of each of its parts into the perpendicular distance of its centre from the given plane or axis; distinguish the moments into positive and negative, according as the centres of the parts lie to one side or the other of the plane: the difference of the two sums will be the resultant moment of the figure relatively to the given plane or axis, and is to be regarded as positive or negative, according as the sum of the positive or negative moments is the greater.

2. *To find the perpendicular distance of the centre of an irregular figure from a given plane or axis.*

**RULE.**—Divide the moment of that figure relatively to the given plane or axis by its magnitude; the quotient will be the perpendicular distance of its centre from the given plane or axis.

3. *To find the centre of a figure consisting of two parts whose centres are known.* (Fig. 114.)

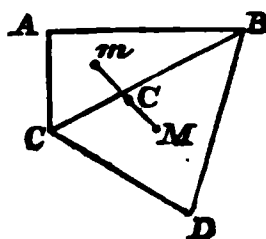
**RULE.**—Multiply the distance between the two known centres by the magnitude of either of the parts, and divide the product by the magnitude of the whole figure; the quotient will be the distance of the centre of the whole figure from the centre of the other part, the centre of the whole figure being in the straight line joining the centres of the two parts.

*Ex.:* Let ABCD be such a figure, M and m the magnitude of its two respective parts, M + m the magnitude of the whole figure, D the distance between the centres M and m of the two parts, and C the centre of the whole figure.

$$MC = \frac{m \times D}{M + m}$$

$$mC = \frac{M \times D}{M + m}$$

FIG. 114.



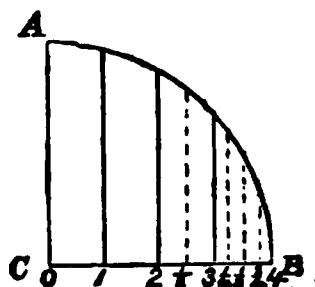
4. *To find the centre of any plane area by means of ordinates.* (Fig. 115.)

Let ABC, the quadrant of a circle, be such an area; CB the base line, divided into a number of equal parts by ordinates; AC the transverse axis traversing its origin.

1st. *Determine the perpendicular distance of the centre of the quadrant from the transverse axis in the following manner:—*

**RULE.**—Multiply each ordinate by its distance from the transverse axis; consider the products as ordinates of a new curve of the same length as the given figure: the area of that curve, found by the proper rule, will be the moment of the figure relatively to the transverse

FIG. 115.



axis; this moment, divided by the whole area of the figure, will give the perpendicular distance of its centre from the transverse axis.

In algebraical symbols the moment of a plane figure relatively to its transverse axis, and found by the above rule, is expressed thus:—

$$\int y dx.$$

*Note.*—In practice it is better to proceed as follows:—Multiply the ordinates first by their multipliers, and then those products by the number of intervals from the origin; take the sum of those products and multiply it by  $\frac{1}{3}$ rd of a whole interval squared, if Simpson's first rule is used, by  $\frac{3}{8}$ ths of a whole interval squared, if Simpson's second rule is used, and so on for the other rules.

*Example.*

| No. of Intervals             | Ordinates | Multipliers    | Products                                   | Products x No. of Intervals from Origin    |
|------------------------------|-----------|----------------|--|--|
| 0                            | 16.0000   | 1              | 16.0000                                    | .00000                                     |
| 1                            | 15.4919   | 4              | 61.9676                                    | 61.9676                                    |
| 2                            | 13.8564   | $1\frac{1}{2}$ | 20.7846                                    | 41.5692                                    |
| $2\frac{1}{2}$               | 12.4900   | 2              | 24.9800                                    | 62.4500                                    |
| 3                            | 10.5830   | $\frac{3}{4}$  | 7.93725                                    | 23.81175                                   |
| $3\frac{1}{4}$               | 9.3274    | 1              | 9.3274                                     | 30.31405                                   |
| $3\frac{1}{2}$               | 7.7460    | $\frac{1}{2}$  | 3.8730                                     | 13.5555                                    |
| $3\frac{3}{4}$               | 5.5678    | 1              | 5.5678                                     | 20.87925                                   |
|                              | 0.0000    | $\frac{1}{4}$  | 0.0000                                     | .00000                                     |
|                              |           |                | Interval 150.43765                         | Interval <sup>2</sup> 254.54735            |
|                              |           |                | $\frac{150.43765}{3} = \frac{50.14588}{1}$ | $\frac{254.54735}{3} = \frac{84.84912}{1}$ |
| Approximate area = 200.58353 |           |                |  | Approx. moment = 1357.585                  |

Moment 1357.585  
Area 200.5835 = 6.768 { approximate perpendicular distance of centre from the transverse axis.

2nd. Find the perpendicular distance of its centre from the base line.

**RULE.**—Square each ordinate, and take the half-squares as ordinates for a new curve of the same length as the figure; the area of that curve, found by the proper rule, will be the moment of the figure relatively to the base line: this moment, divided by the whole area of the figure, will give the perpendicular distance of its centre from the base line.

In algebraical symbols the moment of a plane figure relatively to its base line, found by the above rule, is expressed thus:—

$$\int \frac{y^2}{2} dx.$$

*Example.*

| No. of Intervals | Ordinates | Half-squares | Multipliers | Products  |
|------------------|-----------|--------------|-------------|-----------|
| 0                | 16.0000   | 128.0000     | 1           | 128.0000  |
| 1                | 15.4919   | 119.9995     | 1           | 479.9980  |
| 2                | 13.8564   | 95.9999      | 2           | 191.9998  |
| 3                | 10.5830   | 55.9999      | 4           | 223.9996  |
| 4                | 0.0000    | 0.0000       | 1           | 0.0000    |
| Interval         |           |              |             | 1023.9974 |
|                  |           |              |             | 3         |

Approximate moment = 1365.5298

Moment 1365.3298

Area 201.0624

= 6.796 { approximate perpendicular distance of centre from base.

Actual moment = 1365.3

Actual area = 201.0624

5. To find the centre of a plane area bounded by a curve and two radii by means of polar co-ordinates. (See fig. 82.)

1st. Determine the perpendicular distance of its centre from a plane traversing the pole and at right angles to one of the bounding radii, called the first radius, in the following manner:

**RULE.** Divide the angle subtended by the arc into a convenient number of equiangular intervals by means of radii; measure the lengths of the radii from the pole to the arc, and multiply the third part of the cube of each of them by the cosine of the angle which they respectively make with the first radius; treat these products by one of the rules applicable to finding the area of a plane curve (the only difference being that the common interval is taken in circular measure); the result will be the moment of the figure relatively to the plane traversing the pole: this moment, divided by the area of the figure, will give the perpendicular distance of its centre from the plane traversing the pole.

*Example.*

| No. of Radii | Radii | Cubes of Radii | Angles with First Radius | Cosines | Products | Simpson's Multipliers | Products  |
|--------------|-------|----------------|--------------------------|---------|----------|-----------------------|-----------|
| 1            | 12    | 576            | 0°                       | 1.0000  | 576.0000 | 1                     | 576.0000  |
| 2            | 12    | 576            | 5°                       | .9962   | 573.8112 | 4                     | 2295.2448 |
| 3            | 12    | 576            | 10°                      | .9848   | 566.1448 | 2                     | 1132.2896 |
| 4            | 12    | 576            | 15°                      | .9659   | 556.3584 | 4                     | 2225.4336 |
| 5            | 12    | 576            | 20°                      | .9397   | 541.2672 | 1                     | 541.2672  |
|              |       |                |                          |         |          |                       | 5770.2852 |

Interval in circular measure = .0291

Moment relatively to plane traversing pole = 187.013844



$$\frac{\text{Moment } 197.01384}{\text{Area } 25.1327} = 7.839 \left\{ \begin{array}{l} \text{perpendicular distance of centre} \\ \text{from plane traversing pole.} \end{array} \right.$$

In algebraical symbols the moment, as here found, is expressed thus:—

$$\int \frac{r^3}{3} \cos \theta d\theta.$$

*2nd.* Determine the moment of the figure relatively to the first radius precisely in the same way as in the foregoing rule, with the exception that sines must be used in the place of cosines; this moment, divided by the area of the figure, will give the perpendicular distance of its centre from the first radius.

*Note.*—It is usual, in practice, to defer the division of the cubes of the radii by 3 until after the addition of the products.

*Example.*

| No. of Radii                        | Radii | Cubes of Radii<br>3 | Angles with First Radius | Sines of Angles | Products | Simpson's Multipliers | Products  |
|-------------------------------------|-------|---------------------|--------------------------|-----------------|----------|-----------------------|-----------|
| 1                                   | 12    | 576                 | 0°                       | .0000           | .0000    | 1                     | .0000     |
| 2                                   | 12    | 576                 | 5°                       | .0872           | 50.2272  | 4                     | 200.9088  |
| 3                                   | 12    | 576                 | 10°                      | .1736           | 99.9936  | 2                     | 199.9972  |
| 4                                   | 12    | 576                 | 15°                      | .2588           | 149.0688 | 4                     | 596.2752  |
| 5                                   | 12    | 576                 | 20°                      | .3420           | 196.9920 | 1                     | 196.9920  |
|                                     |       |                     |                          |                 |          |                       | 1194.1732 |
| Interval in circular measure        |       |                     |                          |                 |          |                       | = .0291   |
| 3                                   |       |                     |                          |                 |          |                       |           |
| Moment relatively to first radius = |       |                     |                          |                 |          |                       | 34.750440 |

$$\frac{\text{Moment } 34.75044}{\text{Area } 25.1327} = 1.38 \left\{ \begin{array}{l} \text{perpendicular distance of centre from} \\ \text{first radius.} \end{array} \right.$$

In algebraical symbols the moment as here found is expressed thus:—

$$\int \frac{r^3}{3} \sin \theta d\theta.$$

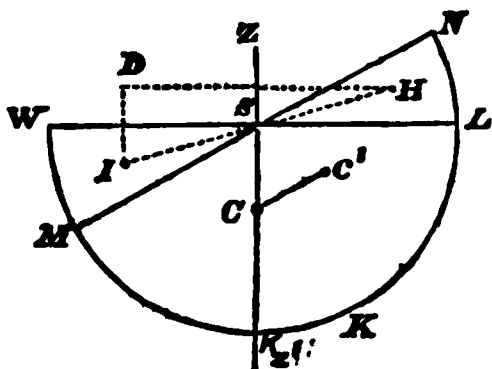
6. To find the perpendicular distance of the centre of a solid, bounded on one side by a curved surface (figs. 101 and 102), from a plane perpendicular to a given axis at a given point.

**RULE.**—Proceed as in Rule 4, p. 73, to find the moment relatively to the plane, substituting sectional areas for breadths; then divide the moment by the volume (as found by Rule 2, p. 44): the quotient will be the required distance. To determine the centre completely, find its distance from three planes no two of which are parallel.

7. *Having the moment and centre of a figure relatively to a given plane, to find the new moment and centre of the figure relatively to the same plane when a part of the figure is shifted.* (Fig. 116.)

In the figure  $WLK$  let  $C$  be its centre, and  $ZZ'$  a plane with respect to which the moment of the figure is known; suppose the part  $WSM$  to be transferred to the new position  $SNL$ , so as to alter the shape of the figure from  $WLK$  to  $MNK$ ; let  $I$  be the original and  $H$  the new centre of the shifted part: then the moment of the figure  $MNK$  relatively to the plane  $ZZ'$  is found as follows:—

FIG. 116.



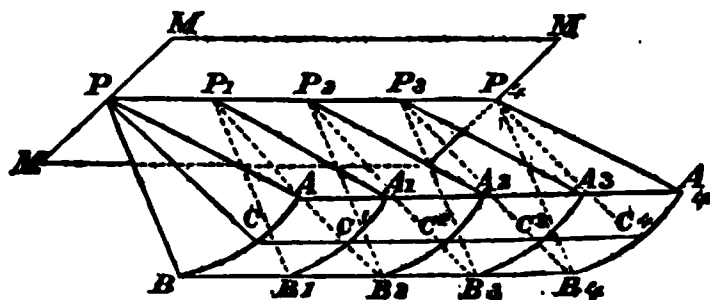
**RULE.**—Measure the distance, perpendicular to the plane of moments, between the centres of the original and new position of the shifted part, as  $HD$ , and multiply it by the magnitude of the shifted part; the product will be the moment required. *The new position of the entire figure is then found by the following rule:—*

**RULE.**—Multiply the distance between the centres of the original and new position of the shifted part by the magnitude of that part; that product, divided by the magnitude of the whole figure, will give the distance the centre has traversed in the direction in which the part has been shifted, and in a plane parallel to a line joining the centres of the original and new position of the shifted part, as from  $C$  to  $C'$  in fig. 116.

8. *To find the centre of a wedge-shaped solid (fig. 117) by means of polar co-ordinates.*

1st. *Determine the perpendicular distances of its centre relatively to a transverse sectional plane, as  $PAB$ .*

FIG. 117.



**RULE.**—Divide the solid by a number of parallel and equidistant planes, as  $PAB$ ,  $P_1A_1B_1$ ,  $P_2A_2B_2$ , &c.; then multiply each sectional area by its distance from the plane  $PAB$ ; treat the products as though they were the ordinates of a curve of the same length as the figure; the area of that curve, found by the proper rule, will be the moment of the figure relatively to the plane  $PAB$ : that moment, divided by the volume of the figure, will be the distance required.

*2nd. Determine the perpendicular distance of its centre relatively to a longitudinal plane passing through its edge, as MPM, perpendicular to the first radius, PB.*

**RULE.**—Divide the figure by a number of longitudinal planes radiating from the edge MPM at equiangular intervals (as PP<sub>1</sub>AA<sub>1</sub>, PP<sub>2</sub>BB<sub>2</sub>, PP<sub>3</sub>CC<sub>3</sub>); also divide the length of the figure into a number of equal intervals by ordinates, and treat each of the longitudinal planes as follows:—Measure its ordinates, take the third part of their cubes, and treat those quantities as if they were ordinates of a new curve; that is, find its area by one of Simpson's rules: the area of that new curve is termed the moment of inertia of the longitudinal plane in question. Then multiply each moment of inertia of the several planes by the cosine of the angle made by the plane to which it belongs with the plane PB, and treat these products by a proper set of Simpson's multipliers; add together the products, and multiply the sum by  $\frac{1}{3}$  of the common angular interval in circular measure if Simpson's first rule is used, and by  $\frac{3}{8}$  if Simpson's second rule is used. The result will be the moment of the figure relatively to the plane MPM. This moment, divided by the volume of the figure, will be the distance required.

The algebraical expression for the moment as found in this rule is

$$\int \int \frac{r^3}{3} \cos \theta d\omega d\theta.$$

*3rd. Determine the perpendicular distance of its centre relatively to a longitudinal plane passing through its edge, and a radius PP'BB', by the foregoing rule, with the exception of multiplying by sines instead of cosines.*

*Note.*—In practice it is usual to defer the division of the cubes of the radii by 3 until after the addition of the products.

#### MOMENTS OF INERTIA AND RADII OF GYRATION.

1. *To find the moment of inertia of a body about a given axis.*

**RULE.**—Conceive the body to be divided into an indefinitely great number of small parts; multiply the mass (or weight) of each of these small parts into the square of its perpendicular distance from the given axis: the sum of all these products as obtained will be the moment of the body about the given axis.

2. *To find the square of the radius of gyration of a body about a given axis.*

**RULE.**—Divide the moment of inertia of the body relatively to the given axis by the mass (or weight) of the body.

3. *Given the moment of inertia of a body about an axis traversing its centre of gravity in a given direction, to find its moment of inertia about another axis parallel to the first.*

RULE.—Multiply the mass (or weight) of the body by the square of the perpendicular distance between the two axes, and to the product add the given moment of inertia.

4. *Given the separate moments of inertia of a set of bodies about parallel axes traversing their several centres of gravity, to find the moment of inertia of these bodies about a common axis parallel to their separate axes.*

RULE.—Multiply the mass (or weight) of each body by the square of the perpendicular distance of its centre of gravity from the common axis; the sum of all these products, together with all the separate moments of inertia, will be the combined moment of inertia.

5. *Given the square of the radius of gyration of a body about an axis traversing its centre in a given direction, to find the square of the radius of gyration about another axis parallel to the first.*

RULE.—Square the perpendicular distance between the two axes, and add the product to the given square of the radius of gyration.

6. *To find the moment of inertia of a plane area, bounded on one side by a curve (see fig. 115), relatively to its base line.*

RULE.—Divide the base line into a suitable number of equal intervals, and measure ordinates at the points of division; take the third part of the cube of each of these ordinates, and treat those quantities so computed as the ordinates of a new curve: the area of that new curve, found by the proper rule, will be the moment of inertia required. In algebraical symbols the above rule is expressed thus:—

$$\int \frac{y^3}{3} dw.$$

*Notes.*—When the moment of inertia is required as a whole, and not in separate parts, it is usual to postpone the division of the cubes till the end of the calculation.

7. *To find the moment of inertia of a plane area, bounded on one side by a curve, relatively to one of its ordinates.*

RULE.—Multiply each ordinate by its proper multiplier, according to one of the rules for finding the area of such figures; then multiply the product by the square of the number of whole intervals that the ordinate in question is distant from the

ordinate taken as the axis of moments: the sum of these products, multiplied by  $\frac{1}{3}$  or  $\frac{2}{3}$  the cube of a whole interval, according as Simpson's first or second rule is used, will be the moment of inertia required.

In algebraical symbols this rule is expressed thus:—

$$\int x^2 y dx.$$

*Example I.*

**CALCULATION OF MOMENT OF INERTIA OF THE QUADRANT OF A CIRCLE RELATIVELY TO THE BASE LINE.**

| No. of Intervals | Ordinates | Cubes of Ordinates<br>3 | Multipliers    | Products   |
|------------------|-----------|-------------------------|----------------|--|
| 0                | 16·00     | 1365·33                 | 1              | 1865·33  |
| 1                | 15·49     | 1238·89                 | 4              | 4955·56  |
| 2                | 13·86     | 887·50                  | $1\frac{1}{2}$ | 1331·25  |
| $2\frac{1}{2}$   | 12·49     | 649·48                  | 2              | 1298·96  |
| 3                | 10·58     | 394·43                  | $\frac{3}{4}$  | 295·82   |
| $3\frac{1}{4}$   | 9·33      | 270·72                  | 1              | 270·72   |
| $3\frac{1}{2}$   | 7·75      | 155·16                  | $\frac{1}{2}$  | 77·58  |
| $3\frac{3}{4}$   | 5·57      | 57·90                   | 1              | 57·90  |
| 4                | 0·00      | 0·00                    | $\frac{1}{4}$  | 0·00   |
|                  |           |                         |                | Interval $\frac{9653·12}{3} = \frac{3217·71}{1}$ |
|                  |           |                         |                | 12870·82   |

*Example II.*

**CALCULATION OF THE MOMENT OF INERTIA OF THE QUADRANT OF A CIRCLE RELATIVELY TO THE ENDMOST ORDINATE.**

| No. of Intervals | Ordinates | Multipliers    | Products | Squares of Nos. of Intervals | Products  |
|------------------|-----------|----------------|----------|------------------------------|---|
| 0                | 16·0000   | 1              | 16·0000  | 0·00                         | 16·0000   |
| 1                | 15·4919   | 4              | 61·9676  | 1·00                         | 61·9679   |
| 2                | 13·8564   | $1\frac{1}{2}$ | 20·7846  | 4·00                         | 83·1384   |
| $2\frac{1}{2}$   | 12·4900   | 2              | 24·9800  | 6·25                         | 156·1250  |
| 3                | 10·5830   | $\frac{3}{4}$  | 7·93725  | 9·00                         | 71·4353   |
| $3\frac{1}{4}$   | 9·3274    | 1              | 9·3274   | 10·5625                      | 98·5207   |
| $3\frac{1}{2}$   | 7·7460    | $\frac{1}{2}$  | 3·8730   | 12·2500                      | 47·4443   |
| $3\frac{3}{4}$   | 5·5678    | 1              | 5·5678   | 14·0625                      | 78·2972   |
| 4                | 0·0000    | $\frac{1}{4}$  | 0·0000   | 16·0000                      | 0·0000  |
|                  |           |                |          |                              | Interval <sup>2</sup> $\frac{612·9288}{3} = \frac{204·3096}{1}$ |
|                  |           |                |          |                              | Approximate moment of inertia = 13075·8144                      |

TABLE OF SQUARES OF RADII OF GYRATION OF A FEW SPECIAL FIGURES.

| Body   | Axis                   | Radius <sup>2</sup> =                  |
|--|------------------------|--|
| 1. Rectangle; sides $a$ and $b$  | side $a$               | $\frac{b^2}{3}$                        |
| 2. Triangle; sides $a, b, c$ , heights $a', b', c'$                                    | side $a$               | $\frac{a'^2}{3}$                       |
| 3. Circle or ellipse; diameters $a, b$   | diameter $a$           | $\frac{b^2}{16}$                       |
| 4. Common parabola; height $a$ , base $b$  | base $b$               | $\frac{6a^3}{35}$                      |
| 5. Sphere; radius $r$  | diameter               | $\frac{2r^2}{5}$                       |
| 6. Spheroid of revolution, polar semi-axis $a$ , equatorial radius $r$                 | polar axis             | $\frac{3r^2}{5}$                       |
| 7. Ellipsoid; semi-axes $a, b, c$  | axis $2a$              | $\frac{b^2 + c^2}{5}$                  |
| 8. Spherical shell; external radius $r$ , internal radius $r'$                         | diameter               | $\frac{2(r^5 - r'^5)}{5(r^3 - r'^3)}$  |
| 9. Circular cylinder; length $2a$ , radius $r$   | longitudinal axis $2a$ | $\frac{r^2}{2}$                        |
| 10. Circular cylinder; length $2a$ , radius $r$  | transverse diameter    | $\frac{r^2}{4} + \frac{a^2}{3}$        |
| 11. Hollow circular cylinder: length $2a$ , external radius $r$ , internal radius $r'$ | longitudinal axis $2a$ | $\frac{r^2 + r'^2}{2}$                 |
| 12. Hollow circular cylinder; length $2a$ , external radius $r$ , internal radius $r'$ | transverse diameter    | $\frac{r^2 + r'^2}{4} + \frac{a^2}{3}$ |
| 13. Elliptic cylinder; length $2a$ , transverse semi-axes $b, c$                       | longitudinal axis $2a$ | $\frac{b^2 + c^2}{4}$                  |
| 14. Elliptic cylinder; length $2a$ , transverse semi-axes $b, c$                       | transverse axis $2b$   | $\frac{c^2}{4} + \frac{a^2}{3}$        |
| 15. Rectangular prism; dimensions $2a, 2b, 2c$   | axis $2a$              | $\frac{b^2 + c^2}{3}$                  |
| 16. Rhombic prism; length $2a$ , diagonals $2b, 2c$                                    | axis $2a$              | $\frac{b^2 + c^2}{6}$                  |
| 17. Rhombic prism; length $2a$ , diagonals $2b, 2c$                                    | diagonal $2b$          | $\frac{c^2}{6} + \frac{a^2}{3}$        |

Moment of inertia = square of radius of gyration  $\times$  the mass (or weight) of the figure.

## TONNAGE.

## REGISTER OR NEW MEASUREMENT TONNAGE.

THE gross register tonnage of a ship expresses her entire cubical capacity in tons of 100 cubic feet each, and may be found approximately by the following formula:—

L = the inside length on upper deck from plank at stem to plank at stern.

B = the inside main breadth from ceiling to ceiling.

D = the inside midship depth from upper deck to ceiling at limber strake.

$$\text{Register tonnage} = \frac{L \times B \times D}{100} C.$$

*Value of C.*

|                               |   |     |
|-------------------------------|---|-----|
| Sailing ships                 | { cotton and sugar ships, old full form | .8  |
|                               | { ships of the present usual form       | .7  |
| Steam vessels<br>and clippers | { ships of two decks . . . .            | .65 |
|                               | { ships of three decks . . . .          | .68 |
| Yachts                        | { above sixty tons . . . .              | .5  |
|                               | { under sixty tons . . . .              | .45 |

*To Calculate the Gross Register Tonnage.*

The tonnage deck is the upper deck in all vessels under three decks, in all other vessels the second deck from below.

Measurements to be expressed in feet and the decimals of a foot.

The length for register tonnage is taken from inside of plank at stem to inside of midship stern timber, or plank there, as the case may be, and is taken on the tonnage deck; the length so taken (having made deductions for the rake of stem and stern, if any, in the thickness of the deck, and one-third of the round of the beam) is to be divided into the prescribed number of equal parts, according to the length, as follows:—

| Length.  | No. of Intervals. |
|--|-------------------|
| Not exceeding 50 feet and under . . . .              | 4                 |
| Exceeding 50 feet and not exceeding 120 feet. . . .  | 6                 |
| Exceeding 120 feet and not exceeding 180 feet. . . . | 8                 |
| Exceeding 180 feet and not exceeding 225 feet. . . . | 10                |
| Exceeding 225 feet . . . . .                         | 12                |

Transverse sections are then measured at each of the points of division, as follows:—

The total depths of the transverse sections are measured from the under side of the tonnage deck to the ceiling at the inner edge of limber strake, deducting one-third of the round of the beam. The depths so taken are to be divided into four equal parts, if midship depth should not exceed sixteen feet; otherwise into six equal parts.

The breadths are measured horizontally at the points of division, and also at the upper and lower points of each depth, each measurement extending to the average thickness of that part of the ceiling which is between the points of measurement.

The areas of the transverse sections are then computed by Simpson's first rule (p. 38), and then the capacity of the ship is computed by the same rule (Rule 2, p. 44)—that is, the areas are treated as the ordinates of a new curve of the same length as the vessel; and the area of that new curve, found by Simpson's first rule, will be the capacity of the vessel in cubic feet, which being divided by 100 gives the gross register tonnage.

The capacity of the poop, deck houses, and other permanently enclosed spaces available for cargo or passengers is to be measured and included in the register tonnage, but the following deductions are allowed, the remainder then being deemed the *register tonnage* of the ship.

*Deductions Allowed.*—(1) Buildings for the shelter of passengers only; (2) space allotted to crew (for crew space see p. 114); (3) space occupied by the propelling power.

#### FACTORS FOR MEASUREMENT AND DEAD-WEIGHT CARGOES.

1. *To ascertain approximately for an average length of voyage the measurement cargo, at 40 feet to the ton, which a ship can carry.*

**RULE.**—Multiply the number of register tons by the factor 1.875, and the product will be the approximate measurement cargo.

2. *To ascertain approximately the dead-weight cargo in tons which a ship can carry on an average length of voyage.*

**RULE.**—Multiply the number of register tons by 1.5, and the product will be the approximate dead-weight cargo required.

With regard to the cargoes of coasters and colliers as ascertained above, about 10 per cent. may be added to the said results, while about 10 per cent. may be deducted in the cases of larger vessels going longer voyages.

In the case of measurement cargoes of steam vessels the spaces occupied by the machinery, fuel, and passenger cabins under the deck must be deducted from the space or tonnage under the deck before the application of the measurement factor thereto.

In the case of dead-weight cargoes, the weight of machinery, water in the boilers, and fuel must be deducted from the whole dead weight, as ascertained above by the application of the dead-weight factor.

The deductions necessary to be made for provisions, stores, &c., are allowed for in the selection of the two factors.



## BUILDER'S TONNAGE, OR OLD MEASUREMENT TONNAGE.

*To Compute the Builder's Tonnage.*

**RULE.**—Measure the length of the vessel along the rabbet of the keel from the back of the main stern-post to a perpendicular line let fall from the fore part of the main stem under the bowsprit; measure also the extreme breadth to the outside planking, exclusive of doubling planks. Three-fifths of that breadth is to be subtracted from the length; the remainder is called the length of keel for tonnage. Multiply the length of keel for tonnage by the breadth, that product by the half-breadth, and divide by 94; the quotient will be the tonnage.

If  $L$  = length,  $B$  = breadth, then

$$\text{Tonnage (B.O.M.)} = \frac{(L - \frac{3}{5}B) \times B \times \frac{1}{2}B}{94}.$$

## MEASUREMENT OF YACHTS FOR TONNAGE.

*Royal Thames Yacht Club.*

**RULE.**—Measure the length of the yacht in a straight line at the deck from the fore part of the stem to the after part of the stern-post, from which deduct the extreme breadth, which is measured from the outside of the outside planking; the remainder is the length for tonnage. Multiply the length for tonnage by the extreme breadth, that product by half the extreme breadth, and divide the result by 94; the quotient will be the tonnage. If any part of the stem or stern-post project beyond the length as taken above, such projection or projections shall, for the purpose of finding the tonnage, be added to the length taken as before mentioned. All fractional parts of a ton shall be considered as a ton. The measurement to be taken either above or below the main-wale. If  $L$  = length,  $B$  = breadth, then

$$\text{Tonnage} = \frac{(L - B) \times B \times \frac{1}{2}B}{94}.$$

*Corinthian and the New Thames Yacht Club.*

**RULE.**—Measure the length and breadth as in the foregoing rule, and the depth up to the top of the covering board; multiply the length, breadth, and depth together, and divide the result by 200: the quotient will be the tonnage.

If  $L$  = length,  $B$  = breadth,  $D$  = depth, then

$$\text{Tonnage} = \frac{L \times B \times D}{200}.$$

# TABLE OF THE TONNAGES OF VESSELS ACCORDING TO BUILDER'S MEASUREMENT.

In the following tables tonnages are only given for vessels whose lengths are multiples of 10, except at the head of each group, where the tonnage for each extra foot of length up to 9 feet is given, in order that the tonnages of vessels whose lengths are not given in these tables may be found by a simple addition, as per example.

*Ex.*—Required the tonnage of a vessel 207 feet long and 22·5 feet beam.

Tonnage for 200 feet length =  $402\frac{19}{64}\cdot812$

Tonnage for extra 7 feet length =  $18\frac{79}{64}\cdot875$

Tonnage for 207 feet length =  $421\frac{5}{64}\cdot687$

*Note.*—In the tables the ninety-fourths of a ton are divided from the tons by a dash; thus,  $126\frac{19}{64}\cdot125 = 126-18\cdot125$ .

| Lgth.<br>in Ft. | TONS     | Lgth.<br>in Ft. | TONS      | Lgth.<br>in Ft. | TONS      | Lgth.<br>in Ft. | TONS      |
|-----------------|----------|-----------------|-----------|-----------------|-----------|-----------------|-----------|
| 10 FEET BEAM    |          |                 |           |                 |           |                 |           |
| 1               | 0-50     | 5               | 2-62      | 9               | 4-74      | 60              | 28-68     |
| 2               | 1-6      | 6               | 3-18      | 30              | 12-72     | 70              | 34-4      |
| 3               | 1-56     | 7               | 3-68      | 40              | 18-8      | 80              | 39-34     |
| 4               | 2-12     | 8               | 4-24      | 50              | 23-38     | 90              | 44-64     |
| 10·5 FEET BEAM  |          |                 |           |                 |           |                 |           |
| 1               | 0-55·125 | 5               | 2-87·625  | 9               | 5-26·125  | 60              | 31-46·213 |
| 2               | 1-16·25  | 6               | 3-48·75   | 30              | 13-84·463 | 70              | 37-33·463 |
| 3               | 1-71·375 | 7               | 4-9·875   | 40              | 19-71·713 | 80              | 43-20·713 |
| 4               | 2-32·5   | 8               | 4-65·0    | 50              | 25-58·963 | 90              | 49-7·963  |
| 11 FEET BEAM    |          |                 |           |                 |           |                 |           |
| 1               | 0-60·5   | 6               | 3-81·0    | 40              | 21-46·7   | 90              | 53-63·7   |
| 2               | 1-27·0   | 7               | 4-47·5    | 50              | 27-87·7   | 100             | 60-10·7   |
| 3               | 1-87·5   | 8               | 5-14·0    | 60              | 34-34·7   | 110             | 66-51·7   |
| 4               | 2-54·0   | 9               | 5-74·5    | 70              | 40-75·7   | 120             | 72-92·7   |
| 5               | 3-20·5   | 30              | 15-5·7    | 80              | 47-22·7   | 130             | 79-39·7   |
| 11·5 FEET BEAM  |          |                 |           |                 |           |                 |           |
| 1               | 0-66·125 | 6               | 4-20·75   | 40              | 23-26·738 | 90              | 58-42·988 |
| 2               | 1-38·25  | 7               | 4-86·875  | 50              | 30-29·988 | 100             | 65-46·238 |
| 3               | 2-10·375 | 8               | 5-59·0    | 60              | 37-33·238 | 110             | 72-49·488 |
| 4               | 2-76·5   | 9               | 6-31·125  | 70              | 44-36·488 | 120             | 79-52·738 |
| 5               | 3-48·625 | 30              | 16-23·488 | 80              | 51-39·738 | 130             | 86-55·988 |
| 12 FEET BEAM    |          |                 |           |                 |           |                 |           |
| 1               | 0-72     | 6               | 4-56      | 50              | 32-73     | 100             | 71-7      |
| 2               | 1-50     | 7               | 5-34      | 60              | 40-41     | 110             | 78-69     |
| 3               | 2-28     | 8               | 6-12      | 70              | 48-9      | 120             | 86-37     |
| 4               | 3-6      | 9               | 6-84      | 80              | 55-71     | 130             | 94-5      |
| 5               | 3-78     | 40              | 25-11     | 90              | 63-39     | 140             | 101-67    |

## TONNAGE TABLES.

| Length<br>in Ft. | TONS     | Length<br>in Ft. | TONS      | Length<br>in Ft. | TONS       | Length<br>in Ft. | TONS       |
|------------------|----------|------------------|-----------|------------------|------------|------------------|------------|
| 12.5 FEET BEAM   |          |                  |           |                  |            |                  |            |
| 1                | 0-78.125 | 6                | 4-92.75   | 50               | 35-30.313  | 100              | 75-82.563  |
| 2                | 1-62.25  | 7                | 5-76.875  | 60               | 43-59.563  | 110              | 85-17.813  |
| 3                | 2-46.375 | 8                | 6-61.0    | 70               | 51-88.813  | 120              | 93-47.063  |
| 4                | 3-30.5   | 9                | 7-45.125  | 80               | 60-24.063  | 130              | 101-76.313 |
| 5                | 4-14.625 | 40               | 27-1.063  | 90               | 68-53.813  | 140              | 110-11.563 |
| 13 FEET BEAM     |          |                  |           |                  |            |                  |            |
| 1                | 0-84.5   | 6                | 5-37.0    | 50               | 87-87.9    | 100              | 82-82.9    |
| 2                | 1-75.0   | 7                | 6-27.5    | 60               | 46-86.9    | 110              | 91-81.9    |
| 3                | 2-65.5   | 8                | 7-18.0    | 70               | 55-85.9    | 120              | 100-80.9   |
| 4                | 3-56.0   | 9                | 8-8.5     | 80               | 64-84.9    | 130              | 109-79.9   |
| 5                | 4-46.5   | 40               | 28-88.9   | 90               | 73-83.9    | 140              | 118-78.9   |
| 13.5 FEET BEAM   |          |                  |           |                  |            |                  |            |
| 1                | 0-91.125 | 6                | 5-76.75   | 50               | 40-58.138  | 100              | 89-8.888   |
| 2                | 1-88.25  | 7                | 6-73.875  | 60               | 50-29.388  | 110              | 98-73.638  |
| 3                | 2-85.375 | 8                | 7-71.0    | 70               | 60-0.638   | 120              | 108-44.888 |
| 4                | 3-82.5   | 9                | 8-68.125  | 80               | 89-65.888  | 130              | 118-16.138 |
| 5                | 4-79.625 | 40               | 30-86.888 | 90               | 79-37.138  | 140              | 127-81.388 |
| 14 FEET BEAM     |          |                  |           |                  |            |                  |            |
| 1                | 1-4      | 6                | 6-24      | 50               | 43-34      | 100              | 95-46      |
| 2                | 2-8      | 7                | 7-28      | 60               | 53-74      | 110              | 105-86     |
| 3                | 3-12     | 8                | 8-32      | 70               | 64-20      | 120              | 116-32     |
| 4                | 4-16     | 9                | 9-36      | 80               | 74-60      | 130              | 126-72     |
| 5                | 5-20     | 40               | 32-88     | 90               | 85-6       | 140              | 137-18     |
| 14.5 FEET BEAM   |          |                  |           |                  |            |                  |            |
| 1                | 1-11.125 | 6                | 6-66.75   | 60               | 57-34.913  | 110              | 113-27.163 |
| 2                | 2-22.25  | 7                | 7-77.875  | 70               | 38-52.163  | 120              | 124-44.413 |
| 3                | 3-33.375 | 8                | 8-89.0    | 80               | 79-69.413  | 130              | 135-61.663 |
| 4                | 4-44.5   | 9                | 10-6.125  | 90               | 90-86.663  | 140              | 146-78.913 |
| 5                | 5-55.625 | 50               | 46-17.663 | 100              | 102-9.913  | 150              | 158-2.163  |
| 15 FEET BEAM     |          |                  |           |                  |            |                  |            |
| 1                | 1-18.5   | 6                | 7-17.0    | 60               | 61-3.5     | 110              | 120-82.5   |
| 2                | 2-37.0   | 7                | 8-35.5    | 70               | 73-0.5     | 120              | 132-79.5   |
| 3                | 3-55.5   | 8                | 9-54.0    | 80               | 84-91.5    | 130              | 144-76.5   |
| 4                | 4-74.0   | 9                | 10-72.5   | 90               | 96-88.5    | 140              | 156-73.5   |
| 5                | 5-92.5   | 50               | 49-6.5    | 100              | 108-85.5   | 150              | 168-70.5   |
| 15.5 FEET BEAM   |          |                  |           |                  |            |                  |            |
| 1                | 1-26     | 7                | 8-88      | 80               | 90-32.838  | 140              | 167-2.338  |
| 2                | 2-52     | 8                | 10-21     | 90               | 103-12.088 | 150              | 179-75.588 |
| 3                | 3-78     | 9                | 11-47     | 100              | 115-85.338 | 160              | 192-54.838 |
| 4                | 5-10     | 50               | 52-1.088  | 110              | 128-64.588 | 170              | 205-34.088 |
| 5                | 6-36     | 60               | 64-74.338 | 120              | 141-43.838 | 180              | 218-13.838 |
| 6                | 7-62     | 70               | 77-53.588 | 130              | 154-23.088 | 190              | 230-86.588 |

| Depth<br>in Ft. | TONS      | Depth<br>in Ft. | TONS       | Depth<br>in Ft. | TONS       | Depth<br>in Ft. | TONS       |
|-----------------|-----------|-----------------|------------|-----------------|------------|-----------------|------------|
| 16 FEET BEAM    |           |                 |            |                 |            |                 |            |
| 1               | 1-34      | 7               | 9-50       | 80              | 95-81      | 140             | 177-53     |
| 2               | 2-68      | 8               | 10-84      | 90              | 109-45     | 150             | 191-17     |
| 3               | 4-8       | 9               | 12-24      | 100             | 123-0      | 160             | 204-75     |
| 4               | 5-42      | 50              | 55-1       | 110             | 136-67     | 170             | 218-39     |
| 5               | 6-76      | 60              | 68-59      | 120             | 150-31     | 180             | 232-3      |
| 6               | 8-16      | 70              | 82-23      | 130             | 163-89     | 190             | 245-61     |
| 16.5 FEET BEAM  |           |                 |            |                 |            |                 |            |
| 1               | 1-42-125  | 7               | 10-12-875  | 80              | 101-48-363 | 140             | 188-37-863 |
| 2               | 2-84-25   | 8               | 11-55 0    | 90              | 115-93-613 | 150             | 202-83-113 |
| 3               | 4-82-375  | 9               | 13-3-125   | 100             | 130-44-863 | 160             | 217-34-363 |
| 4               | 5-74-5    | 50              | 58-6-613   | 110             | 144-90-113 | 170             | 231-79-613 |
| 5               | 7-28-825  | 60              | 72-51-863  | 120             | 159-41-363 | 180             | 246-30-863 |
| 6               | 8-64-75   | 70              | 87-3-113   | 130             | 173-86-613 | 190             | 260-76-113 |
| 17 FEET BEAM    |           |                 |            |                 |            |                 |            |
| 1               | 1-50-5    | 7               | 10-71-5    | 80              | 107-28-1   | 140             | 199-50-1   |
| 2               | 3-7-0     | 8               | 12-28 0    | 90              | 122-63-1   | 150             | 214-85-1   |
| 3               | 4-57-5    | 9               | 13-78-5    | 100             | 138-4-1    | 160             | 230-26-1   |
| 4               | 6-14-0    | 50              | 61-17-1    | 110             | 153-39-1   | 170             | 245-61-1   |
| 5               | 7-64-5    | 60              | 76-52-1    | 120             | 168-74-1   | 180             | 261-2-1    |
| 6               | 9-21-0    | 70              | 91-87-1    | 130             | 184-15-1   | 190             | 276-37-1   |
| 17.5 FEET BEAM  |           |                 |            |                 |            |                 |            |
| 1               | 1-59-125  | 7               | 11-37-875  | 80              | 113-20-188 | 140             | 210-89-688 |
| 2               | 3-24-25   | 8               | 13-3-0     | 90              | 129-47-438 | 150             | 227-22-938 |
| 3               | 4-83-375  | 9               | 14-62-125  | 100             | 145-74-688 | 160             | 243-50-188 |
| 4               | 6-48-5    | 50              | 64-32-438  | 110             | 162-7-938  | 170             | 259-77-438 |
| 5               | 8-13-625  | 60              | 80-59-688  | 120             | 178-35-188 | 180             | 276-10-688 |
| 6               | 9-72-75   | 70              | 96-86-938  | 130             | 194-62-438 | 190             | 292-37-938 |
| 18 FEET BEAM    |           |                 |            |                 |            |                 |            |
| 1               | 1-68      | 7               | 12-6       | 80              | 119-24     | 140             | 222-62     |
| 2               | 3-42      | 8               | 13-74      | 90              | 136-46     | 150             | 239-84     |
| 3               | 5-16      | 9               | 15-48      | 100             | 153-68     | 160             | 257-12     |
| 4               | 6-84      | 50              | 67-52      | 110             | 170-90     | 170             | 274-34     |
| 5               | 8-58      | 60              | 84-74      | 120             | 188-18     | 180             | 291-56     |
| 6               | 10-32     | 70              | 102-2      | 130             | 205-40     | 190             | 308-78     |
| 18.5 FEET BEAM  |           |                 |            |                 |            |                 |            |
| 1               | 1-77-125  | 8               | 14-53 0    | 100             | 161-79-013 | 170             | 289-25-763 |
| 2               | 3-60-25   | 9               | 16-36-125  | 110             | 180-4-263  | 180             | 307-45-013 |
| 3               | 5-43-375  | 50              | 70-76-763  | 120             | 198-23-513 | 190             | 325-64-263 |
| 4               | 7-26-5    | 60              | 89-2-013   | 130             | 216-42-763 | 200             | 343-83-513 |
| 5               | 9-9-625   | 70              | 107-21-263 | 140             | 234-62-013 | 210             | 362-8-763  |
| 6               | 10-86-75  | 80              | 125-40-513 | 150             | 252-81-263 | 220             | 380-28-013 |
| 7               | 12-69-875 | 90              | 143-59-763 | 160             | 271-6-513  | 230             | 398-47-263 |

## TONNAGE TABLES.

| Depth<br>in Ft. | TONS      | Depth<br>in Ft. | TONS       | Depth<br>in Ft. | TONS       | Depth<br>in Ft. | TONS       |
|-----------------|-----------|-----------------|------------|-----------------|------------|-----------------|------------|
| 19 FEET BEAM    |           |                 |            |                 |            |                 |            |
| 1               | 1-86.5    | 8               | 15-34.0    | 100             | 170-12.3   | 170             | 304-51.3   |
| 2               | 3-79.0    | 9               | 17-26.5    | 110             | 189-31.3   | 180             | 323-70.3   |
| 3               | 5-71.5    | 50              | 74-11.3    | 120             | 208-50.3   | 190             | 342-89.3   |
| 4               | 7-64.0    | 60              | 93-30.3    | 130             | 227-69.3   | 200             | 362-14.3   |
| 5               | 9-56.5    | 70              | 112-49.3   | 140             | 246-88.3   | 210             | 381-33.3   |
| 6               | 11-49.0   | 80              | 131-68.3   | 150             | 266-13.3   | 220             | 400-52.3   |
| 7               | 13-41.5   | 90              | 150-87.3   | 160             | 285-32.3   | 230             | 419-71.3   |
| 19.5 FEET BEAM  |           |                 |            |                 |            |                 |            |
| 1               | 2-2-125   | 9               | 18-19-125  | 120             | 219-4-538  | 200             | 380-80-538 |
| 2               | 4-4-25    | 60              | 77-43-788  | 130             | 239-25-788 | 210             | 401-7-788  |
| 3               | 6-6-375   | 60              | 97-65-038  | 140             | 259-47-088 | 220             | 421-29-088 |
| 4               | 8-8-5     | 70              | 117-86-288 | 150             | 279-68-288 | 230             | 441-50-288 |
| 5               | 10-10-625 | 80              | 138-13-538 | 160             | 299-89-538 | 240             | 461-71-538 |
| 6               | 12-12-75  | 90              | 158-34-788 | 170             | 320-16-788 | 250             | 481-92-788 |
| 7               | 14-14-875 | 100             | 178-56-038 | 180             | 340-38-038 | 260             | 502-20-038 |
| 8               | 16-17-0   | 110             | 198-77-288 | 190             | 360-59-288 | 270             | 522-41-288 |
| 20 FEET BEAM    |           |                 |            |                 |            |                 |            |
| 1               | 2-12      | 9               | 19-14      | 130             | 251-6      | 210             | 421-26     |
| 2               | 4-24      | 60              | 102-12     | 140             | 272-32     | 220             | 442-52     |
| 3               | 6-36      | 70              | 123-38     | 150             | 293-58     | 230             | 463-78     |
| 4               | 8-48      | 80              | 144-64     | 160             | 314-84     | 240             | 485-10     |
| 5               | 10-60     | 90              | 165-90     | 170             | 336-16     | 250             | 506-36     |
| 6               | 12-72     | 100             | 187-22     | 180             | 357-42     | 260             | 527-62     |
| 7               | 14-84     | 110             | 208-48     | 190             | 378-68     | 270             | 548-88     |
| 8               | 17-2      | 120             | 229-74     | 200             | 400-0      | 280             | 570-20     |
| 20.5 FEET BEAM  |           |                 |            |                 |            |                 |            |
| 1               | 2-22-125  | 9               | 20-11-125  | 130             | 263-9-713  | 210             | 441-87-713 |
| 2               | 4-44-25   | 60              | 106-58-963 | 140             | 285-42-963 | 220             | 464-26-963 |
| 3               | 6-66-375  | 70              | 128-92-213 | 150             | 307-76-213 | 230             | 486-60-213 |
| 4               | 8-88-5    | 80              | 151-31-463 | 160             | 330-15-463 | 240             | 508-93-463 |
| 5               | 11-16-625 | 90              | 173-64-713 | 170             | 352-48-713 | 250             | 531-32-713 |
| 6               | 13-38-75  | 100             | 196-3-963  | 180             | 374-81-963 | 260             | 553-65-963 |
| 7               | 15-60-875 | 110             | 218-37-213 | 190             | 397-21-213 | 270             | 576-5-213  |
| 8               | 17-83-0   | 120             | 240-70-463 | 200             | 419-54-463 | 280             | 598-38-463 |
| 21 FEET BEAM    |           |                 |            |                 |            |                 |            |
| 1               | 3-32.5    | 9               | 21-10.5    | 130             | 275-36.7   | 210             | 463-4.7    |
| 2               | 4-65.0    | 60              | 111-17.7   | 140             | 298-79.7   | 220             | 486-47.7   |
| 3               | 7-3.5     | 70              | 134-60.7   | 150             | 322-28.7   | 230             | 509-90.7   |
| 4               | 9-38.0    | 80              | 158-9.7    | 160             | 345-71.7   | 240             | 533-39.7   |
| 5               | 11-68.5   | 90              | 181-52.7   | 170             | 369-20.7   | 250             | 556-82.7   |
| 6               | 14-7.0    | 100             | 205-1.7    | 180             | 392-63.7   | 260             | 580-31.7   |
| 7               | 16-39.5   | 110             | 228-44.7   | 190             | 416-12.7   | 270             | 603-74.7   |
| 8               | 18-72.0   | 120             | 251-87.7   | 200             | 439-55.7   | 280             | 627-23.7   |

| Lgth.<br>in Ft. | TONS      | Lgth.<br>in Ft. | TONS       | Lgth.<br>in Ft. | TONS       | Lgth.<br>in Ft. | TONS       |
|-----------------|-----------|-----------------|------------|-----------------|------------|-----------------|------------|
| 21.5 FEET BEAM  |           |                 |            |                 |            |                 |            |
| 1               | 2-43.125  | 9               | 22-12.125  | 130             | 287-86.738 | 210             | 484-58.738 |
| 2               | 4-86.25   | 60              | 115-75.988 | 140             | 312-47.988 | 220             | 509-19.988 |
| 3               | 7-35.375  | 70              | 140-37.238 | 150             | 337-9.238  | 230             | 533-75.238 |
| 4               | 9-78.5    | 80              | 164-92.488 | 160             | 361-64.488 | 240             | 558-36.488 |
| 5               | 12-27.625 | 90              | 189-53.738 | 170             | 386-25.738 | 250             | 582-91.738 |
| 6               | 14-70.75  | 100             | 214-14.988 | 180             | 410-80.988 | 260             | 607-52.988 |
| 7               | 17-19.875 | 110             | 238-70.238 | 190             | 435-42.238 | 270             | 632-14.238 |
| 8               | 19-63.0   | 120             | 263-31.488 | 200             | 460-3.488  | 280             | 656-69.488 |

|              |       |     |        |     |        |     |        |
|--------------|-------|-----|--------|-----|--------|-----|--------|
| 22 FEET BEAM |       |     |        |     |        |     |        |
| 1            | 2-54  | 9   | 23-16  | 130 | 300-65 | 210 | 506-61 |
| 2            | 5-14  | 60  | 120-45 | 140 | 326-41 | 220 | 532-37 |
| 3            | 7-68  | 70  | 146-21 | 150 | 352-17 | 230 | 558-13 |
| 4            | 10-28 | 80  | 171-91 | 160 | 377-87 | 240 | 583-83 |
| 5            | 12-82 | 90  | 197-67 | 170 | 403-63 | 250 | 609-59 |
| 6            | 15-42 | 100 | 223-43 | 180 | 429-39 | 260 | 635-35 |
| 7            | 18-2  | 110 | 249-19 | 190 | 455-15 | 270 | 661-11 |
| 8            | 20-56 | 120 | 274-89 | 200 | 480-85 | 280 | 686-81 |

|                |           |     |            |     |            |     |            |
|----------------|-----------|-----|------------|-----|------------|-----|------------|
| 22.5 FEET BEAM |           |     |            |     |            |     |            |
| 1              | 2-65.125  | 9   | 24-22.125  | 130 | 313-67.063 | 210 | 529-13.063 |
| 2              | 5-36.25   | 60  | 125-20.313 | 140 | 340-60.313 | 220 | 556-6.313  |
| 3              | 8-7.375   | 70  | 152-13.563 | 150 | 367-53.563 | 230 | 582-93.563 |
| 4              | 10-72.5   | 80  | 179-6.813  | 160 | 394-46.813 | 240 | 609-86.813 |
| 5              | 13-43.625 | 90  | 206-0.063  | 170 | 421-40.063 | 250 | 636-80.063 |
| 6              | 16-14.75  | 100 | 232-87.313 | 180 | 448-33.313 | 260 | 663-73.313 |
| 7              | 18-79.875 | 110 | 259-80.563 | 190 | 475-26.563 | 270 | 690-66.563 |
| 8              | 21-51.0   | 120 | 286-73.813 | 200 | 502-19.813 | 280 | 717-59.813 |

|              |         |     |          |     |          |     |          |
|--------------|---------|-----|----------|-----|----------|-----|----------|
| 23 FEET BEAM |         |     |          |     |          |     |          |
| 1            | 2-76.5  | 9   | 25-30.5  | 130 | 326-90.9 | 210 | 552-6.9  |
| 2            | 5-59.0  | 60  | 129-93.9 | 140 | 355-9.9  | 220 | 580-19.9 |
| 3            | 8-41.5  | 70  | 158-12.9 | 150 | 383-22.9 | 230 | 608-32.9 |
| 4            | 11-24.0 | 80  | 186-25.9 | 160 | 411-35.9 | 240 | 636-45.9 |
| 5            | 14-6.5  | 90  | 214-38.9 | 170 | 439-48.9 | 250 | 664-58.9 |
| 6            | 16-83.0 | 100 | 242-51.9 | 180 | 467-61.9 | 260 | 692-71.9 |
| 7            | 19-65.5 | 110 | 270-64.9 | 190 | 495-74.9 | 270 | 720-84.9 |
| 8            | 22-48.0 | 120 | 298-77.9 | 200 | 523-87.9 | 280 | 749-3.9  |

|                |           |     |            |     |            |     |            |
|----------------|-----------|-----|------------|-----|------------|-----|------------|
| 23.5 FEET BEAM |           |     |            |     |            |     |            |
| 1              | 2-88.125  | 9   | 26-41.125  | 140 | 369-78.138 | 220 | 604-78.138 |
| 2              | 5-82.25   | 70  | 164-19.388 | 150 | 399-19.388 | 230 | 634-19.388 |
| 3              | 8-76.375  | 80  | 193-54.638 | 160 | 428-54.638 | 240 | 663-54.638 |
| 4              | 11-70.5   | 90  | 222-89.888 | 170 | 457-89.888 | 250 | 692-89.888 |
| 5              | 14-64.625 | 100 | 252-31.138 | 180 | 487-31.138 | 260 | 722-31.138 |
| 6              | 17-58.75  | 110 | 281-66.388 | 190 | 516-66.388 | 270 | 751-66.388 |
| 7              | 20-52.875 | 120 | 311-7.638  | 200 | 546-7.638  | 280 | 781-7.638  |
| 8              | 23-47.0   | 130 | 340-42.888 | 210 | 575-42.888 | 290 | 810-42.888 |

## TONNAGE TABLES.

| Lgth.<br>in Ft. | TONS      | Lgth.<br>in Ft. | TONS       | Lgth.<br>in Ft. | TONS        | Lgth.<br>in Ft. | TONS        |
|-----------------|-----------|-----------------|------------|-----------------|-------------|-----------------|-------------|
| 29 FEET BEAM    |           |                 |            |                 |             |                 |             |
| 1               | 4-44.5    | 9               | 40-24.5    | 150             | 593-16.3    | 230             | 951-4.3     |
| 2               | 8-89.0    | 80              | 280-3.3    | 160             | 637-85.3    | 240             | 995-73.8    |
| 3               | 13-39.5   | 90              | 324-72.3   | 170             | 682-60.3    | 250             | 1040-48.3   |
| 4               | 17-84.0   | 100             | 369-47.3   | 180             | 727-35.3    | 260             | 1085-23.3   |
| 5               | 22-34.5   | 110             | 414-22.3   | 190             | 772-10.3    | 270             | 1129-92.3   |
| 6               | 26-79.0   | 120             | 458-91.3   | 200             | 816-79.3    | 280             | 1174-67.3   |
| 7               | 31-29.5   | 130             | 503-66.3   | 210             | 861-54.3    | 290             | 1219-42.3   |
| 8               | 35-74.0   | 140             | 548-41.3   | 220             | 906-29.3    | 300             | 1264-17.3   |
| 29.5 FEET BEAM  |           |                 |            |                 |             |                 |             |
| 1               | 4-59.125  | 9               | 41-62.125  | 150             | 612-39.038  | 230             | 982-69.088  |
| 2               | 9-24.25   | 80              | 288-36.288 | 160             | 658-66.288  | 240             | 1029-2.288  |
| 3               | 13-83.375 | 90              | 334-63.538 | 170             | 704-93.538  | 250             | 1075-29.538 |
| 4               | 18-48.5   | 100             | 380-90.788 | 180             | 751-26.788  | 260             | 1121-56.788 |
| 5               | 23-13.625 | 110             | 427-24.038 | 190             | 797-54.038  | 270             | 1167-84.038 |
| 6               | 27-72.75  | 120             | 473-51.288 | 200             | 843-81.288  | 280             | 1214-17.288 |
| 7               | 32-37.875 | 130             | 519-78.538 | 210             | 890-14.538  | 290             | 1260-44.538 |
| 8               | 37-3.0    | 140             | 566-11.788 | 220             | 936-41.788  | 300             | 1306-71.788 |
| 30 FEET BEAM    |           |                 |            |                 |             |                 |             |
| 1               | 4-74      | 9               | 43-8       | 160             | 679-74      | 240             | 1062-72     |
| 2               | 9-54      | 90              | 344-64     | 170             | 727-62      | 250             | 1110-60     |
| 3               | 14-34     | 100             | 392-52     | 180             | 775-50      | 260             | 1158-48     |
| 4               | 19-14     | 110             | 440-40     | 190             | 823-38      | 270             | 1206-36     |
| 5               | 23-88     | 120             | 488-28     | 200             | 871-26      | 280             | 1254-24     |
| 6               | 28-68     | 130             | 536-16     | 210             | 919-14      | 290             | 1302-12     |
| 7               | 33-48     | 140             | 584-4      | 220             | 967-2       | 300             | 1350-0      |
| 8               | 38-28     | 150             | 631-86     | 230             | 1014-84     | 310             | 1397-82     |
| 30.5 FEET BEAM  |           |                 |            |                 |             |                 |             |
| 1               | 4-89.125  | 9               | 44-50.125  | 160             | 701-14.213  | 240             | 1097-0.213  |
| 2               | 9-84.25   | 90              | 354-73.463 | 170             | 750-59.463  | 250             | 1146-45.463 |
| 3               | 14-79.375 | 100             | 404-24.713 | 180             | 800-10.713  | 260             | 1195-90.713 |
| 4               | 19-74.5   | 110             | 453-69.963 | 190             | 849-55.963  | 270             | 1245-41.963 |
| 5               | 24-69.625 | 120             | 503-21.213 | 200             | 899-7.213   | 280             | 1294-87.213 |
| 6               | 29-64.75  | 130             | 552-66.463 | 210             | 948-52.463  | 290             | 1344-38.463 |
| 7               | 34-59.875 | 140             | 602-17.713 | 220             | 998-3.713   | 300             | 1393-83.713 |
| 8               | 39-55.0   | 150             | 651-62.963 | 230             | 1047-48.963 | 310             | 1443-34.963 |
| 31 FEET BEAM    |           |                 |            |                 |             |                 |             |
| 1               | 5-10.5    | 9               | 46-0.5     | 160             | 722-74.7    | 240             | 1131-68.7   |
| 2               | 10-21.0   | 90              | 364-91.7   | 170             | 773-85.7    | 250             | 1182-79.7   |
| 3               | 15-31.5   | 100             | 416-8.7    | 180             | 825-2.7     | 260             | 1233-90.7   |
| 4               | 20-42.0   | 110             | 467-19.7   | 190             | 876-13.7    | 270             | 1285-7.7    |
| 5               | 25-52.5   | 120             | 518-30.7   | 200             | 927-24.7    | 280             | 1336-18.7   |
| 6               | 30-63.0   | 130             | 569-41.7   | 210             | 978-35.7    | 290             | 1387-29.7   |
| 7               | 35-73.5   | 140             | 620-52.7   | 220             | 1026-49.7   | 300             | 1438-40.7   |
| 8               | 40-84.0   | 150             | 671-63.7   | 230             | 1080-57.7   | 310             | 1489-51.7   |

| Length<br>in Ft. | TONS      | Length<br>in Ft. | TONS       | Length<br>in Ft. | TONS        | Length<br>in Ft. | TONS        |
|------------------|-----------|------------------|------------|------------------|-------------|------------------|-------------|
| 31.5 FEET BEAM   |           |                  |            |                  |             |                  |             |
| 1                | 5-26.125  | 9                | 47-47.125  | 170              | 797-46.488  | 250              | 1219-68.488 |
| 2                | 10-52.25  | 100              | 428-3.738  | 180              | 850-25.738  | 260              | 1272-47.738 |
| 3                | 15-78.375 | 110              | 480-76.988 | 190              | 903-4.988   | 270              | 1325-26.988 |
| 4                | 21-10.5   | 120              | 533-56.238 | 200              | 955-78.238  | 280              | 1378-6.238  |
| 5                | 26-36.625 | 130              | 586-35.488 | 210              | 1008-57.488 | 290              | 1430-79.488 |
| 6                | 31-62.75  | 140              | 639-14.738 | 220              | 1061-36.738 | 300              | 1483-58.738 |
| 7                | 36-88.875 | 150              | 691-87.988 | 230              | 1114-15.988 | 310              | 1536-37.988 |
| 8                | 42-21.0   | 160              | 744-67.238 | 240              | 1116-89.238 | 320              | 1589-17.238 |

|              |       |     |        |     |         |     |         |
|--------------|-------|-----|--------|-----|---------|-----|---------|
| 32 FEET BEAM |       |     |        |     |         |     |         |
| 1            | 5-42  | 100 | 440-9  | 190 | 930-29  | 280 | 1240-49 |
| 2            | 10-84 | 110 | 494-53 | 200 | 984-73  | 290 | 1474-93 |
| 3            | 16-32 | 120 | 549-3  | 210 | 1039-23 | 300 | 1529-43 |
| 4            | 21-74 | 130 | 603-47 | 220 | 1093-67 | 310 | 1583-87 |
| 5            | 27-22 | 140 | 657-91 | 230 | 1148-17 | 320 | 1638-37 |
| 6            | 32-64 | 150 | 712-41 | 240 | 1202-61 | 330 | 1692-81 |
| 7            | 38-12 | 160 | 766-85 | 250 | 1257-11 | 340 | 1747-31 |
| 8            | 43-54 | 170 | 821-35 | 260 | 1311-55 | 350 | 1801-75 |
| 9            | 49-2  | 180 | 875-79 | 270 | 1366-5  | 360 | 1856-25 |

|                |           |     |            |     |             |     |             |
|----------------|-----------|-----|------------|-----|-------------|-----|-------------|
| 32.5 FEET BEAM |           |     |            |     |             |     |             |
| 1              | 5-58.125  | 100 | 452-26.063 | 190 | 957-87.313  | 280 | 1463-54.563 |
| 2              | 11-22.25  | 110 | 508-43.313 | 200 | 1014-10.563 | 290 | 1519-71.813 |
| 3              | 16-80.375 | 120 | 564-60.563 | 210 | 1070-27.813 | 300 | 1575-89.063 |
| 4              | 22-44.5   | 130 | 620-77.813 | 220 | 1126-45.063 | 310 | 1632-12.313 |
| 5              | 28-8.625  | 140 | 677-1.063  | 230 | 1182-62.313 | 320 | 1688-29.563 |
| 6              | 33-66.75  | 150 | 733-18.313 | 240 | 1238-79.563 | 330 | 1744-46.813 |
| 7              | 39-30.875 | 160 | 789-35.563 | 250 | 1295-2.813  | 340 | 1800-64.063 |
| 8              | 44-89.0   | 170 | 845-52.813 | 260 | 1351-20.063 | 350 | 1856-81.313 |
| 9              | 50-53.125 | 180 | 901-70.063 | 270 | 1407-37.313 | 360 | 1913-4.563  |

|              |         |     |          |     |           |     |           |
|--------------|---------|-----|----------|-----|-----------|-----|-----------|
| 33 FEET BEAM |         |     |          |     |           |     |           |
| 1            | 5-74.5  | 100 | 464-52.9 | 190 | 985-83.9  | 280 | 1507-20.9 |
| 2            | 11-55.0 | 110 | 522-45.9 | 200 | 1043-76.9 | 290 | 1565-13.9 |
| 3            | 17-35.5 | 120 | 580-38.9 | 210 | 1101-69.9 | 300 | 1623-6.9  |
| 4            | 23-16.0 | 130 | 638-31.9 | 220 | 1159-62.9 | 310 | 1680-93.9 |
| 5            | 28-90.5 | 140 | 696-24.9 | 230 | 1217-55.9 | 320 | 1738-86.9 |
| 6            | 34-71.0 | 150 | 754-17.9 | 240 | 1275-48.9 | 330 | 1796-79.9 |
| 7            | 40-51.5 | 160 | 812-10.9 | 250 | 1333-41.9 | 340 | 1854-72.9 |
| 8            | 46-32.0 | 170 | 870-3.9  | 260 | 1391-34.9 | 350 | 1912-65.9 |
| 9            | 52-12.5 | 180 | 927-90.9 | 270 | 1449-27.9 | 360 | 1970-58.9 |

|                |           |     |            |     |            |     |             |
|----------------|-----------|-----|------------|-----|------------|-----|-------------|
| 33.5 FEET BEAM |           |     |            |     |            |     |             |
| 1              | 5-91.125  | 6   | 35-76.75   | 110 | 536-61.138 | 160 | 835-11.388  |
| 2              | 11-88.25  | 7   | 41-73.875  | 120 | 596-32.388 | 170 | 894-76.638  |
| 3              | 17-85.375 | 8   | 47-71.0    | 130 | 656-3.638  | 180 | 954-47.888  |
| 4              | 23-82.5   | 9   | 53-68.125  | 140 | 715-68.888 | 190 | 1014-19.138 |
| 5              | 29-79.625 | 100 | 476-89.888 | 150 | 775-40.138 | 200 | 1073-84.388 |



## TONNAGE TABLES.

| Lgth.<br>in Ft. | TONS    | Lgth.<br>in Ft. | TONS     | Lgth.<br>in Ft. | TONS     | Lgth.<br>in Ft. | TONS      |
|-----------------|---------|-----------------|----------|-----------------|----------|-----------------|-----------|
| 29 FEET BEAM    |         |                 |          |                 |          |                 |           |
| 1               | 4-44.5  | 9               | 40-24.5  | 150             | 593-16.3 | 230             | 951-4.3   |
| 2               | 8-89.0  | 80              | 280-3.3  | 160             | 637-85.3 | 240             | 995-73.8  |
| 3               | 13-39.5 | 90              | 324-72.3 | 170             | 682-60.3 | 250             | 1040-48.3 |
| 4               | 17-84.0 | 100             | 369-47.3 | 180             | 727-35.3 | 260             | 1085-23.3 |
| 5               | 22-34.5 | 110             | 414-22.3 | 190             | 772-10.3 | 270             | 1129-92.3 |
| 6               | 26-79.0 | 120             | 458-91.3 | 200             | 816-79.3 | 280             | 1174-67.3 |
| 7               | 31-29.5 | 130             | 503-66.3 | 210             | 861-54.3 | 290             | 1219-42.3 |
| 8               | 35-74.0 | 140             | 548-41.3 | 220             | 906-29.3 | 300             | 1264-17.3 |

|                |           |     |            |     |            |     |             |
|----------------|-----------|-----|------------|-----|------------|-----|-------------|
| 29.5 FEET BEAM |           |     |            |     |            |     |             |
| 1              | 4-59.125  | 9   | 41-62.125  | 150 | 612-39.038 | 230 | 982-69.088  |
| 2              | 9-24.25   | 80  | 288-36.288 | 160 | 658-66.288 | 240 | 1029-2.288  |
| 3              | 13-83.375 | 90  | 334-63.538 | 170 | 704-93.538 | 250 | 1075-29.538 |
| 4              | 18-48.5   | 100 | 380-90.788 | 180 | 751-26.788 | 260 | 1121-56.788 |
| 5              | 23-13.625 | 110 | 427-24.038 | 190 | 797-54.038 | 270 | 1167-84.038 |
| 6              | 27-72.75  | 120 | 473-51.288 | 200 | 843-81.288 | 280 | 1214-17.288 |
| 7              | 32-37.875 | 130 | 519-78.538 | 210 | 890-14.538 | 290 | 1260-44.538 |
| 8              | 37-3.0    | 140 | 566-11.788 | 220 | 936-41.788 | 300 | 1306-71.788 |

|              |       |     |        |     |         |     |         |
|--------------|-------|-----|--------|-----|---------|-----|---------|
| 30 FEET BEAM |       |     |        |     |         |     |         |
| 1            | 4-74  | 9   | 43-8   | 160 | 679-74  | 240 | 1062-72 |
| 2            | 9-54  | 90  | 344-64 | 170 | 727-62  | 250 | 1110-60 |
| 3            | 14-34 | 100 | 392-52 | 180 | 775-50  | 260 | 1158-48 |
| 4            | 19-14 | 110 | 440-40 | 190 | 823-38  | 270 | 1206-36 |
| 5            | 23-88 | 120 | 488-28 | 200 | 871-26  | 280 | 1254-24 |
| 6            | 28-68 | 130 | 536-16 | 210 | 919-14  | 290 | 1302-12 |
| 7            | 33-48 | 140 | 584-4  | 220 | 967-2   | 300 | 1350-0  |
| 8            | 38-28 | 150 | 631-86 | 230 | 1014-84 | 310 | 1397-82 |

|                |           |     |            |     |             |     |             |
|----------------|-----------|-----|------------|-----|-------------|-----|-------------|
| 30.5 FEET BEAM |           |     |            |     |             |     |             |
| 1              | 4-89.125  | 9   | 44-50.125  | 160 | 701-14.213  | 240 | 1097-0.213  |
| 2              | 9-84.25   | 90  | 354-73.463 | 170 | 750-59.463  | 250 | 1146-45.463 |
| 3              | 14-79.375 | 100 | 404-24.713 | 180 | 800-10.713  | 260 | 1195-90.713 |
| 4              | 19-74.5   | 110 | 453-69.963 | 190 | 849-55.963  | 270 | 1245-41.963 |
| 5              | 24-69.625 | 120 | 503-21.213 | 200 | 899-7.213   | 280 | 1294-87.213 |
| 6              | 29-64.75  | 130 | 552-66.463 | 210 | 948-52.463  | 290 | 1344-38.463 |
| 7              | 34-59.875 | 140 | 602-17.713 | 220 | 998-3.713   | 300 | 1393-83.713 |
| 8              | 39-55.0   | 150 | 651-62.963 | 230 | 1047-48.963 | 310 | 1443-34.963 |

|              |         |     |          |     |           |     |           |
|--------------|---------|-----|----------|-----|-----------|-----|-----------|
| 31 FEET BEAM |         |     |          |     |           |     |           |
| 1            | 5-10.5  | 9   | 46-0.5   | 160 | 722-74.7  | 240 | 1131-68.7 |
| 2            | 10-21.0 | 90  | 364-91.7 | 170 | 773-85.7  | 250 | 1182-79.7 |
| 3            | 15-31.5 | 100 | 416-8.7  | 180 | 825-2.7   | 260 | 1233-90.7 |
| 4            | 20-42.0 | 110 | 467-19.7 | 190 | 876-13.7  | 270 | 1285-7.7  |
| 5            | 25-52.5 | 120 | 518-30.7 | 200 | 927-24.7  | 280 | 1336-18.7 |
| 6            | 30-63.0 | 130 | 569-41.7 | 210 | 978-35.7  | 290 | 1387-29.7 |
| 7            | 35-73.5 | 140 | 620-52.7 | 220 | 1026-49.7 | 300 | 1438-40.7 |
| 8            | 40-84.0 | 150 | 671-63.7 | 230 | 1080-57.7 | 310 | 1489-51.7 |

TONNAGE TABLES.

33

| Length<br>in Ft. | TONS      | Length<br>in Ft. | TONS       | Length<br>in Ft. | TONS        | Length<br>in Ft. | TONS        |
|------------------|-----------|------------------|------------|------------------|-------------|------------------|-------------|
| 81-0 FEET BEAM   |           |                  |            |                  |             |                  |             |
| 1                | 5-26-125  | 9                | 47-47-125  | 170              | 797-46-488  | 250              | 1219-68-488 |
| 2                | 10-52-25  | 100              | 428-3-738  | 180              | 850-25-788  | 260              | 1272-47-738 |
| 3                | 15-78-375 | 110              | 480-76-988 | 190              | 903-4-988   | 270              | 1325-26-988 |
| 4                | 21-10-5   | 120              | 533-56-238 | 200              | 955-78-238  | 280              | 1378-6-238  |
| 5                | 26-36-625 | 130              | 586-35-488 | 210              | 1008-57-488 | 290              | 1430-79-488 |
| 6                | 31-62-75  | 140              | 639-14-738 | 220              | 1061-36-738 | 300              | 1483-58-738 |
| 7                | 36-88-875 | 150              | 691-87-988 | 230              | 1114-15-988 | 310              | 1536-37-988 |
| 8                | 42-21-0   | 160              | 744-67-238 | 240              | 1116-89-238 | 320              | 1589-17-238 |
| 83 FEET BEAM     |           |                  |            |                  |             |                  |             |
| 1                | 5-42      | 100              | 440-9      | 190              | 930-29      | 280              | 1240-49     |
| 2                | 10-84     | 110              | 494-53     | 200              | 984-73      | 290              | 1474-93     |
| 3                | 16-32     | 120              | 549-3      | 210              | 1039-23     | 300              | 1529-43     |
| 4                | 21-74     | 130              | 603-47     | 220              | 1093-67     | 310              | 1583-87     |
| 5                | 27-22     | 140              | 657-91     | 230              | 1148-17     | 320              | 1638-37     |
| 6                | 32-64     | 150              | 712-41     | 240              | 1202-61     | 330              | 1692-81     |
| 7                | 38-12     | 160              | 766-85     | 250              | 1257-11     | 340              | 1747-31     |
| 8                | 43-54     | 170              | 821-35     | 260              | 1311-55     | 350              | 1801-75     |
| 9                | 49-2      | 180              | 875-79     | 270              | 1366-5      | 360              | 1856-25     |
| 85 FEET BEAM     |           |                  |            |                  |             |                  |             |
| 1                | 5-58-125  | 100              | 452-26-063 | 190              | 957-87-313  | 280              | 1463-54-563 |
| 2                | 11-22-25  | 110              | 508-43-313 | 200              | 1014-10-563 | 290              | 1519-71-813 |
| 3                | 16-80-375 | 120              | 564-60-563 | 210              | 1070-27-813 | 300              | 1575-89-063 |
| 4                | 22-44-5   | 130              | 620-77-813 | 220              | 1126-45-063 | 310              | 1632-12-313 |
| 5                | 28-8-625  | 140              | 677-1-063  | 230              | 1182-62-313 | 320              | 1688-29-563 |
| 6                | 33-66-75  | 150              | 733-18-313 | 240              | 1238-79-563 | 330              | 1744-46-813 |
| 7                | 39-30-875 | 160              | 789-35-563 | 250              | 1295-2-313  | 340              | 1800-64-063 |
| 8                | 44-89-0   | 170              | 845-52-813 | 260              | 1351-20-063 | 350              | 1856-81-313 |
| 9                | 50-53-125 | 180              | 901-70-063 | 270              | 1407-37-313 | 360              | 1913-4-563  |
| 87 FEET BEAM     |           |                  |            |                  |             |                  |             |
| 1                | 5-74-5    | 100              | 464-52-9   | 190              | 985-83-9    | 280              | 1607-20-9   |
| 2                | 11-55-0   | 110              | 522-45-9   | 200              | 1043-76-9   | 290              | 1565-13-9   |
| 3                | 17-85-5   | 120              | 580-38-9   | 210              | 1101-69-9   | 300              | 1623-6-9    |
| 4                | 23-16-0   | 130              | 638-31-9   | 220              | 1159-62-9   | 310              | 1680-93-9   |
| 5                | 28-90-5   | 140              | 696-24-9   | 230              | 1217-55-9   | 320              | 1738-86-9   |
| 6                | 34-71-0   | 150              | 754-17-9   | 240              | 1275-48-9   | 330              | 1796-79-9   |
| 7                | 40-51-5   | 160              | 812-10-9   | 250              | 1333-41-9   | 340              | 1854-72-9   |
| 8                | 46-32-0   | 170              | 870-3-9    | 260              | 1391-34-9   | 350              | 1912-65-9   |
| 9                | 52-12-5   | 180              | 927-30-9   | 270              | 1449-27-9   | 360              | 1970-58-9   |
| 89 FEET BEAM     |           |                  |            |                  |             |                  |             |
| 1                | 5-91-125  | 6                | 35-76-75   | 110              | 596-61-138  | 160              | 885-11-388  |
| 2                | 11-88-25  | 7                | 41-72-875  | 120              | 656-32-388  | 170              | 894-76-638  |
| 3                | 17-85-375 | 8                | 47-71-0    | 130              | 656-3-638   | 180              | 964-47-888  |
| 4                | 23-82-5   | 9                | 53-68-125  | 140              | 715-68-888  | 190              | 1014-18-138 |
| 5                | 29-79-625 | 100              | 476-89-888 | 150              | 775-40-138  | 200              | 1073-24-388 |

| INCH           | FEET      | INCH | FEET        | INCH | FEET        | INCH | FEET        |
|----------------|-----------|------|-------------|------|-------------|------|-------------|
| 33 FEET BEAM   |           |      |             |      |             |      |             |
| 11 1/2         | 15 1/2    | 270  | 1452-5000   | 310  | 1670-72 688 | 340  | 1909-57-888 |
| 11 1/2         | 16 1/2    | 270  | 1451-71 138 | 310  | 1730-50 138 | 350  | 1969-29-188 |
| 11 1/2         | 17 1/2    | 270  | 1551 42 388 | 320  | 1790-21 388 | 360  | 2029-0-388  |
| 34 FEET BEAM   |           |      |             |      |             |      |             |
| 1              | 8 1/4     | 100  | 489 42      | 190  | 1042-80     | 280  | 1596-24     |
| 2              | 12 28     | 110  | 550 88      | 200  | 1104-32     | 290  | 1657-70     |
| 3              | 16 42     | 120  | 612 40      | 210  | 1165-78     | 300  | 1719-22     |
| 4              | 24 36     | 130  | 673 86      | 220  | 1227 30     | 310  | 1780-68     |
| 5              | 30 10     | 140  | 735 38      | 230  | 1288-76     | 320  | 1842-20     |
| 6              | 36 31     | 150  | 796 84      | 240  | 1350-28     | 330  | 1903-66     |
| 7              | 43 4      | 160  | 858 36      | 250  | 1411-74     | 340  | 1965-18     |
| 8              | 49 18     | 170  | 919 82      | 260  | 1473-26     | 350  | 2026-64     |
| 9              | 56 32     | 180  | 981 34      | 270  | 1534-72     | 360  | 2088-16     |
| 34 6 FEET BEAM |           |      |             |      |             |      |             |
| 1              | 8 31 126  | 100  | 502 5-413   | 190  | 1071-80-663 | 280  | 1641-61-913 |
| 2              | 12 69 26  | 110  | 566 34 663  | 200  | 1135-15 913 | 290  | 1704-91-163 |
| 3              | 16 93 315 | 120  | 628 63 913  | 210  | 1198-45 163 | 300  | 1768-26-413 |
| 4              | 20 303    | 130  | 691 93 163  | 220  | 1261-74 413 | 310  | 1831-55-663 |
| 5              | 24 31 693 | 140  | 755 28 413  | 230  | 1325-9-663  | 320  | 1894-84-913 |
| 6              | 28 192 3  | 150  | 818 87-663  | 240  | 1388-38-913 | 330  | 1958-20-163 |
| 7              | 32 208 3  | 160  | 881 86 913  | 250  | 1451-68-163 | 340  | 2021-49-413 |
| 8              | 36 61 0   | 170  | 945 22 163  | 260  | 1515-3-413  | 350  | 2084-78-663 |
| 9              | 40 92 193 | 180  | 1008 31 413 | 270  | 1578-37-663 | 360  | 2148-13-913 |
| 35 FEET BEAM   |           |      |             |      |             |      |             |
| 1              | 8 48 3    | 100  | 514 71 3    | 190  | 1101-18 3   | 280  | 1687-59 5   |
| 2              | 12 41 3   | 110  | 578 86 3    | 200  | 1165-33 3   | 290  | 1752-74 5   |
| 3              | 16 31 3   | 120  | 643 7 3     | 210  | 1231-48 3   | 300  | 1817-89 5   |
| 4              | 20 31 3   | 130  | 708 22 3    | 220  | 1297-63 3   | 310  | 1883-10 5   |
| 5              | 24 31 3   | 140  | 773 37 3    | 230  | 1363-78 3   | 320  | 1948-25 5   |
| 6              | 28 31 3   | 150  | 838 52 3    | 240  | 1429-93 3   | 330  | 2013-40 5   |
| 7              | 32 31 3   | 160  | 903 67 3    | 250  | 1495-108 3  | 340  | 2078-55 5   |
| 8              | 36 31 3   | 170  | 968 82 3    | 260  | 1561-123 3  | 350  | 2143-70 5   |
| 9              | 40 31 3   | 180  | 1033 97 3   | 270  | 1627-138 3  | 360  | 2208-85 5   |
| 36 FEET BEAM   |           |      |             |      |             |      |             |
| 1              | 8 54 3    | 100  | 526 86 3    | 190  | 1113-33 3   | 280  | 1700-108 3  |
| 2              | 12 48 3   | 110  | 591 101 3   | 200  | 1179-48 3   | 290  | 1766-25 3   |
| 3              | 16 42 3   | 120  | 656 116 3   | 210  | 1245-63 3   | 300  | 1832-40 3   |
| 4              | 20 46 3   | 130  | 721 131 3   | 220  | 1311-78 3   | 310  | 1898-55 3   |
| 5              | 24 50 3   | 140  | 786 146 3   | 230  | 1377-93 3   | 320  | 1964-70 3   |
| 6              | 28 54 3   | 150  | 851 161 3   | 240  | 1443-108 3  | 330  | 2030-85 3   |
| 7              | 32 58 3   | 160  | 916 176 3   | 250  | 1509-123 3  | 340  | 2096-100 3  |
| 8              | 36 62 3   | 170  | 981 191 3   | 260  | 1575-138 3  | 350  | 2162-115 3  |
| 9              | 40 66 3   | 180  | 1046 206 3  | 270  | 1641-153 3  | 360  | 2228-130 3  |

| Depth<br>in Ft. | TONS       | Depth<br>in Ft. | TONS        | Depth<br>in Ft. | TONS        | Depth<br>in Ft. | TONS        |
|-----------------|------------|-----------------|-------------|-----------------|-------------|-----------------|-------------|
| 26 FEET BEAM    |            |                 |             |                 |             |                 |             |
| 1               | 6-84       | 110             | 609-37      | 210             | 1298-71     | 310             | 1988-11     |
| 2               | 13-74      | 120             | 678-31      | 220             | 1367-65     | 320             | 2067-5      |
| 3               | 20-64      | 130             | 747-25      | 230             | 1436-59     | 330             | 2125-98     |
| 4               | 27-54      | 140             | 816-19      | 240             | 1505-53     | 340             | 2194-87     |
| 5               | 34-44      | 150             | 885-13      | 250             | 1574-47     | 350             | 2263-81     |
| 6               | 41-34      | 160             | 954-7       | 260             | 1643-41     | 360             | 2332-75     |
| 7               | 48-24      | 170             | 1023-1      | 270             | 1712-35     | 370             | 2401-69     |
| 8               | 55-14      | 180             | 1091-89     | 280             | 1781-29     | 380             | 2470-63     |
| 9               | 62-4       | 190             | 1160-83     | 290             | 1850-23     | 390             | 2539-57     |
| 100             | 540-43     | 200             | 1229-77     | 300             | 1919-17     | 400             | 2608-51     |
| 26.5 FEET BEAM  |            |                 |             |                 |             |                 |             |
| 1               | 7-8-125    | 110             | 624-29-613  | 210             | 1332-90-113 | 310             | 2041-56-613 |
| 2               | 14-16-25   | 120             | 695-16-863  | 220             | 1403-77-368 | 320             | 2112-43-863 |
| 3               | 21-24-375  | 130             | 766-4-113   | 230             | 1474-64-613 | 330             | 2183-31-113 |
| 4               | 28-32-5    | 140             | 836-85-363  | 240             | 1545-51-863 | 340             | 2254-18-363 |
| 5               | 35-40-625  | 150             | 907-72-613  | 250             | 1616-39-113 | 350             | 2325-5-613  |
| 6               | 42-48-75   | 160             | 978-59-863  | 260             | 1687-26-363 | 360             | 2395-86-863 |
| 7               | 49-56-875  | 170             | 1049-47-113 | 270             | 1758-13-613 | 370             | 2466-74-113 |
| 8               | 56-65-0    | 180             | 1120-34-363 | 280             | 1829-0-863  | 380             | 2537-61-363 |
| 9               | 63-73-125  | 190             | 1191-21-613 | 290             | 1899-82-113 | 390             | 2608-48-613 |
| 100             | 553-42-363 | 200             | 1262-8-863  | 300             | 1970-69-363 | 400             | 2679-35-863 |
| 27 FEET BEAM    |            |                 |             |                 |             |                 |             |
| 1               | 7-26-5     | 120             | 712-16-1    | 220             | 1440-34-1   | 320             | 2168-52-1   |
| 2               | 14-53-0    | 130             | 784-93-1    | 230             | 1513-17-1   | 330             | 2241-35-1   |
| 3               | 21-79-5    | 140             | 857-76-1    | 240             | 1586-0-1    | 340             | 2314-18-1   |
| 4               | 29-12-0    | 150             | 930-59-1    | 250             | 1658-77-1   | 350             | 2387-1-1    |
| 5               | 36-38-5    | 160             | 1003-42-1   | 260             | 1731-60-1   | 360             | 2459-78-1   |
| 6               | 43-65-0    | 170             | 1076-25-1   | 270             | 1804-43-1   | 370             | 2532-61-1   |
| 7               | 50-91-5    | 180             | 1149-8-1    | 280             | 1877-26-1   | 380             | 2605-44-1   |
| 8               | 58-24-0    | 190             | 1221-85-1   | 290             | 1950-9-1    | 390             | 2678-27-1   |
| 9               | 65-50-5    | 200             | 1294-68-1   | 300             | 2022-86-1   | 400             | 2751-10-1   |
| 110             | 639-33-1   | 210             | 1367-51-1   | 310             | 2095-69-1   | 410             | 2823-87-1   |
| 27.5 FEET BEAM  |            |                 |             |                 |             |                 |             |
| 1               | 7-45-135   | 120             | 729-28-688  | 220             | 1477-29-188 | 320             | 2225-29-688 |
| 2               | 14-90-25   | 130             | 804-9-938   | 230             | 1552-10-438 | 330             | 2300-10-938 |
| 3               | 22-41-375  | 140             | 878-85-188  | 240             | 1626-85-688 | 340             | 2374-86-188 |
| 4               | 29-86-5    | 150             | 953-66-438  | 250             | 1701-66-938 | 350             | 2449-67-438 |
| 5               | 37-37-625  | 160             | 1028-47-888 | 260             | 1776-48-188 | 360             | 2524-48-688 |
| 6               | 44-82-75   | 170             | 1103-28-938 | 270             | 1851-29-438 | 370             | 2599-29-938 |
| 7               | 52-33-875  | 180             | 1178-10-188 | 280             | 1926-10-688 | 380             | 2674-11-188 |
| 8               | 59-79-0    | 190             | 1252-85-438 | 290             | 2000-85-938 | 390             | 2748-86-438 |
| 9               | 67-30-125  | 200             | 1327-66-688 | 300             | 2075-67-188 | 400             | 2823-67-688 |
| 110             | 634-47-438 | 210             | 1402-47-938 | 310             | 2150-48-438 | 410             | 2898-48-938 |

## TONNAGE TABLES.

| Lgth.<br>in Ft.            | TONS        | Lgth.<br>in Ft. | TONS        | Lgth.<br>in Ft. | TONS        | Lgth.<br>in Ft. | TONS        |
|----------------------------|-------------|-----------------|-------------|-----------------|-------------|-----------------|-------------|
| 33.5 FEET BEAM (concluded) |             |                 |             |                 |             |                 |             |
| 210                        | 1133-55.638 | 250             | 1372-34.638 | 290             | 1611-13.638 | 330             | 1849-86.638 |
| 220                        | 1193-26.888 | 260             | 1432-5.888  | 300             | 1670-78.888 | 340             | 1909-57.888 |
| 230                        | 1252-92.138 | 270             | 1491-71.138 | 310             | 1730-50.188 | 350             | 1969-29.138 |
| 240                        | 1312-63.388 | 280             | 1551-42.388 | 320             | 1790-21.388 | 360             | 2029-0.388  |
| 34 FEET BEAM               |             |                 |             |                 |             |                 |             |
| 1                          | 6-14        | 100             | 489-42      | 190             | 1042-80     | 280             | 1596-24     |
| 2                          | 12-28       | 110             | 550-88      | 200             | 1104-32     | 290             | 1657-70     |
| 3                          | 18-42       | 120             | 612-40      | 210             | 1165-78     | 300             | 1719-22     |
| 4                          | 24-56       | 130             | 673-86      | 220             | 1227-30     | 310             | 1780-68     |
| 5                          | 30-70       | 140             | 735-38      | 230             | 1288-76     | 320             | 1842-20     |
| 6                          | 36-84       | 150             | 796-84      | 240             | 1350-28     | 330             | 1903-66     |
| 7                          | 43-4        | 160             | 858-36      | 250             | 1411-74     | 340             | 1965-18     |
| 8                          | 49-18       | 170             | 919-82      | 260             | 1473-26     | 350             | 2026-64     |
| 9                          | 55-32       | 180             | 981-34      | 270             | 1534-72     | 360             | 2088-16     |
| 34.5 FEET BEAM             |             |                 |             |                 |             |                 |             |
| 1                          | 6-31.125    | 100             | 502-5.413   | 190             | 1071-80.663 | 280             | 1641-61.913 |
| 2                          | 12-62.25    | 110             | 565-34.663  | 200             | 1135-15.913 | 290             | 1704-91.163 |
| 3                          | 18-93.375   | 120             | 628-63.913  | 210             | 1198-45.163 | 300             | 1768-26.413 |
| 4                          | 25-30.5     | 130             | 691-93.163  | 220             | 1261-74.413 | 310             | 1831-55.663 |
| 5                          | 31-61.625   | 140             | 755-28.413  | 230             | 1325-9.663  | 320             | 1894-84.913 |
| 6                          | 37-92.75    | 150             | 818-57.663  | 240             | 1388-38.913 | 330             | 1958-20.163 |
| 7                          | 44-29.875   | 160             | 881-86.913  | 250             | 1451-68.163 | 340             | 2021-49.413 |
| 8                          | 50-61.0     | 170             | 945-22.163  | 260             | 1515-3.413  | 350             | 2084-78.663 |
| 9                          | 56-92.125   | 180             | 1008-51.413 | 270             | 1578-32.663 | 360             | 2148-13.913 |
| 35 FEET BEAM               |             |                 |             |                 |             |                 |             |
| 1                          | 6-48.5      | 100             | 514-71.5    | 190             | 1101-18.5   | 280             | 1687-59.5   |
| 2                          | 13-3.0      | 110             | 579-86.5    | 200             | 1166-33.5   | 290             | 1752-74.5   |
| 3                          | 19-51.5     | 120             | 645-7.5     | 210             | 1231-48.5   | 300             | 1817-89.5   |
| 4                          | 26-6.0      | 130             | 710-22.5    | 220             | 1296-63.5   | 310             | 1883-10.5   |
| 5                          | 32-54.5     | 140             | 775-37.5    | 230             | 1361-78.5   | 320             | 1948-25.5   |
| 6                          | 39-9.0      | 150             | 840-52.5    | 240             | 1426-93.5   | 330             | 2013-40.5   |
| 7                          | 45-57.5     | 160             | 905-67.5    | 250             | 1492-14.5   | 340             | 2078-55.5   |
| 8                          | 52-12.0     | 170             | 970-82.5    | 260             | 1557-29.5   | 350             | 2143-70.5   |
| 9                          | 58-60.5     | 180             | 1036-3.5    | 270             | 1622-44.5   | 360             | 2208-85.5   |
| 35.5 FEET BEAM             |             |                 |             |                 |             |                 |             |
| 1                          | 6-66.125    | 100             | 527-52.838  | 190             | 1130-82.088 | 280             | 1734-17.338 |
| 2                          | 13-38.25    | 110             | 594-56.088  | 200             | 1197-85.338 | 290             | 1801-20.588 |
| 3                          | 20-10.375   | 120             | 661-59.338  | 210             | 1264-88.588 | 300             | 1868-23.838 |
| 4                          | 26-76.5     | 130             | 728-62.588  | 220             | 1331-91.838 | 310             | 1935-27.088 |
| 5                          | 33-48.625   | 140             | 795-65.838  | 230             | 1399-1.088  | 320             | 2002-30.338 |
| 6                          | 40-20.75    | 150             | 862-69.088  | 240             | 1466-4.338  | 330             | 2069-33.588 |
| 7                          | 46-86.875   | 160             | 929-72.338  | 250             | 1533-7.588  | 340             | 2136-36.838 |
| 8                          | 53-59.0     | 170             | 996-75.588  | 260             | 1600-10.838 | 350             | 2203-40.088 |
| 9                          | 60-31.125   | 180             | 1063-78.838 | 270             | 1667-14.088 | 360             | 2270-43.338 |

| Depth<br>in Ft. | TONS       | Depth<br>in Ft. | TONS        | Depth<br>in Ft. | TONS        | Depth<br>in Ft. | TONS        |
|-----------------|------------|-----------------|-------------|-----------------|-------------|-----------------|-------------|
| 36 FEET BEAM    |            |                 |             |                 |             |                 |             |
| 1               | 6-84       | 110             | 609-37      | 210             | 1228-71     | 310             | 1988-11     |
| 2               | 13-74      | 120             | 678-31      | 220             | 1367-65     | 320             | 2057-5      |
| 3               | 20-64      | 130             | 747-25      | 230             | 1436-59     | 330             | 2125-03     |
| 4               | 27-54      | 140             | 816-19      | 240             | 1505-53     | 340             | 2194-87     |
| 5               | 34-44      | 150             | 885-13      | 250             | 1574-47     | 350             | 2263-81     |
| 6               | 41-34      | 160             | 954-7       | 260             | 1643-41     | 360             | 2332-75     |
| 7               | 48-24      | 170             | 1023-1      | 270             | 1712-35     | 370             | 2401-69     |
| 8               | 55-14      | 180             | 1091-89     | 280             | 1781-29     | 380             | 2470-63     |
| 9               | 62-4       | 190             | 1160-83     | 290             | 1850-23     | 390             | 2539-57     |
| 100             | 540-43     | 200             | 1229-77     | 300             | 1919-17     | 400             | 2608-51     |
| 36-5 FEET BEAM  |            |                 |             |                 |             |                 |             |
| 1               | 7-8-125    | 110             | 624-29-613  | 210             | 1332-90-113 | 310             | 2041-56-613 |
| 2               | 14-16-25   | 120             | 693-18-863  | 220             | 1408-77-363 | 320             | 2112-43-863 |
| 3               | 21-24-375  | 130             | 766-4-113   | 230             | 1474-64-613 | 330             | 2183-31-113 |
| 4               | 28-32-5    | 140             | 838-85-363  | 240             | 1545-51-863 | 340             | 2254-18-863 |
| 5               | 35-40-625  | 150             | 907-72-613  | 250             | 1616-39-113 | 350             | 2325-5-613  |
| 6               | 42-48-75   | 160             | 978-59-863  | 260             | 1687-26-363 | 360             | 2395-86-863 |
| 7               | 49-56-875  | 170             | 1049-47-113 | 270             | 1758-13-613 | 370             | 2466-74-113 |
| 8               | 56-65-0    | 180             | 1120-34-363 | 280             | 1829-0-863  | 380             | 2537-61-363 |
| 9               | 63-73-125  | 190             | 1191-21-613 | 290             | 1899-82-113 | 390             | 2608-48-613 |
| 100             | 553-42-363 | 200             | 1262-8-863  | 300             | 1970-69-363 | 400             | 2679-35-863 |
| 37 FEET BEAM    |            |                 |             |                 |             |                 |             |
| 1               | 7-26-5     | 120             | 712-16-1    | 220             | 1440-34-1   | 320             | 2168-52-1   |
| 2               | 14-53-0    | 130             | 784-93-1    | 230             | 1513-17-1   | 330             | 2241-35-1   |
| 3               | 21-79-5    | 140             | 857-76-1    | 240             | 1586-0-1    | 340             | 2314-18-1   |
| 4               | 29-12-0    | 150             | 930-59-1    | 250             | 1658-77-1   | 350             | 2387-1-1    |
| 5               | 36-38-5    | 160             | 1003-42-1   | 260             | 1731-60-1   | 360             | 2459-78-1   |
| 6               | 43-65-0    | 170             | 1076-25-1   | 270             | 1804-43-1   | 370             | 2532-61-1   |
| 7               | 50-91-5    | 180             | 1149-8-1    | 280             | 1877-26-1   | 380             | 2605-44-1   |
| 8               | 58-24-0    | 190             | 1221-85-1   | 290             | 1950-9-1    | 390             | 2678-27-1   |
| 9               | 65-50-5    | 200             | 1294-68-1   | 300             | 2022-86-1   | 400             | 2751-10-1   |
| 110             | 639-33-1   | 210             | 1367-51-1   | 310             | 2095-69-1   | 410             | 2823-87-1   |
| 37-5 FEET BEAM  |            |                 |             |                 |             |                 |             |
| 1               | 7-45-125   | 120             | 729-28-688  | 220             | 1477-29-188 | 320             | 2225-29-688 |
| 2               | 14-90-25   | 130             | 804-9-938   | 230             | 1552-10-438 | 330             | 2300-10-938 |
| 3               | 22-41-375  | 140             | 878-85-188  | 240             | 1626-85-688 | 340             | 2374-86-188 |
| 4               | 29-86-5    | 150             | 953-66-438  | 250             | 1701-66-938 | 350             | 2449-67-438 |
| 5               | 37-37-625  | 160             | 1028-47-688 | 260             | 1776-48-188 | 360             | 2524-48-688 |
| 6               | 44-82-75   | 170             | 1103-28-938 | 270             | 1851-29-438 | 370             | 2599-29-938 |
| 7               | 52-33-875  | 180             | 1178-10-188 | 280             | 1926-10-688 | 380             | 2674-11-188 |
| 8               | 59-79-0    | 190             | 1252-85-438 | 290             | 2000-85-938 | 390             | 2748-86-438 |
| 9               | 67-30-125  | 200             | 1327-66-688 | 300             | 2075-67-188 | 400             | 2823-67-688 |
| 110             | 654-47-438 | 210             | 1402-47-938 | 310             | 2150-48-438 | 410             | 2898-48-938 |

| Length<br>in Ft. | TONS   | Length<br>in Ft. | TONS    | Length<br>in Ft. | TONS    | Length<br>in Ft. | TONS    |
|------------------|--------|------------------|---------|------------------|---------|------------------|---------|
| 26 FEET BEAM     |        |                  |         |                  |         |                  |         |
| 1                | 7-84   | 120              | 746-54  | 220              | 1514-62 | 320              | 2282-70 |
| 2                | 15-34  | 130              | 823-36  | 230              | 1591-44 | 330              | 2359-52 |
| 3                | 23-4   | 140              | 900-18  | 240              | 1668-26 | 340              | 2436-34 |
| 4                | 30-68  | 150              | 977-0   | 250              | 1745-8  | 350              | 2513-16 |
| 5                | 38-38  | 160              | 1053-76 | 260              | 1821-84 | 360              | 2589-92 |
| 6                | 46-8   | 170              | 1130-58 | 270              | 1898-66 | 370              | 2666-74 |
| 7                | 53-72  | 180              | 1207-40 | 280              | 1975-48 | 380              | 2743-56 |
| 8                | 61-42  | 190              | 1284-22 | 290              | 2052-30 | 390              | 2820-38 |
| 9                | 69-12  | 200              | 1361-4  | 300              | 2129-12 | 400              | 2897-20 |
| 110              | 669-62 | 210              | 1437-80 | 310              | 2205-86 | 410              | 2974-2  |

|                |            |     |             |     |             |     |             |
|----------------|------------|-----|-------------|-----|-------------|-----|-------------|
| 28-5 FEET BEAM |            |     |             |     |             |     |             |
| 1              | 7-83-125   | 120 | 763-03-013  | 220 | 1552-89-513 | 320 | 2340-80-013 |
| 2              | 15-72-25   | 130 | 842-78-263  | 230 | 1631-24-763 | 330 | 2419-65-263 |
| 3              | 23-61-375  | 140 | 921-63-513  | 240 | 1710-10-013 | 340 | 2498-50-513 |
| 4              | 31-50-5    | 150 | 1000-48-763 | 250 | 1788-89-263 | 350 | 2577-35-763 |
| 5              | 39-39-625  | 160 | 1079-34-013 | 260 | 1867-74-613 | 360 | 2656-21-013 |
| 6              | 47-28-75   | 170 | 1158-19-263 | 270 | 1946-59-763 | 370 | 2735-6-263  |
| 7              | 55-17-875  | 180 | 1237-4-513  | 280 | 2025-45-013 | 380 | 2813-85-513 |
| 8              | 63-7-0     | 190 | 1315-83-763 | 290 | 2104-30-263 | 390 | 2892-70-763 |
| 9              | 70-90-125  | 200 | 1394-69-013 | 300 | 2183-15-513 | 400 | 2971-56-013 |
| 110            | 685-13-763 | 210 | 1473-54-263 | 310 | 2262-0-763  | 410 | 3050-41-263 |

|              |          |     |           |     |           |     |           |
|--------------|----------|-----|-----------|-----|-----------|-----|-----------|
| 29 FEET BEAM |          |     |           |     |           |     |           |
| 1            | 8-8-5    | 120 | 781-50-3  | 220 | 1590-54-3 | 320 | 2390-58-3 |
| 2            | 16-17-0  | 130 | 862-41-3  | 230 | 1671-45-3 | 330 | 2480-49-3 |
| 3            | 24-25-5  | 140 | 943-32-3  | 240 | 1752-36-8 | 340 | 2561-40-3 |
| 4            | 32-34-0  | 150 | 1024-23-3 | 250 | 1833-27-3 | 350 | 2642-31-3 |
| 5            | 40-42-5  | 160 | 1105-14-3 | 260 | 1914-18-3 | 360 | 2723-22-3 |
| 6            | 48-51-0  | 170 | 1186-5-3  | 270 | 1995-9-3  | 370 | 2804-13-3 |
| 7            | 56-59-5  | 180 | 1266-90-3 | 280 | 2076-0-3  | 380 | 2885-4-3  |
| 8            | 64-68-0  | 190 | 1347-81-3 | 290 | 2156-85-3 | 390 | 2965-89-3 |
| 9            | 72-76-5  | 200 | 1428-72-3 | 300 | 2237-76-3 | 400 | 3046-80-3 |
| 110          | 700-59-3 | 210 | 1509-63-3 | 310 | 2318-67-3 | 410 | 3127-71-3 |

|                |            |     |             |     |             |     |             |
|----------------|------------|-----|-------------|-----|-------------|-----|-------------|
| 29-5 FEET BEAM |            |     |             |     |             |     |             |
| 1              | 8-28-125   | 120 | 799-20-038  | 220 | 1629-12-538 | 320 | 2439-5-038  |
| 2              | 16-56-25   | 130 | 882-19-288  | 230 | 1712-11-788 | 330 | 2542-4-288  |
| 3              | 24-84-375  | 140 | 965-18-538  | 240 | 1795-11-038 | 340 | 2625-3-538  |
| 4              | 33-18-5    | 150 | 1048-17-788 | 250 | 1878-10-288 | 350 | 2708-2-788  |
| 5              | 41-46-625  | 160 | 1131-17-038 | 260 | 1961-9-538  | 360 | 2791-2-038  |
| 6              | 49-74-75   | 170 | 1214-16-288 | 270 | 2044-8-788  | 370 | 2874-1-288  |
| 7              | 58-8-875   | 180 | 1297-15-538 | 280 | 2127-8-038  | 380 | 2957-0-538  |
| 8              | 66-37-0    | 190 | 1380-14-788 | 290 | 2210-7-288  | 390 | 3039-93-788 |
| 9              | 74-65-125  | 200 | 1463-14-038 | 300 | 2293-6-538  | 400 | 3122-93-038 |
| 110            | 716-20-788 | 210 | 1546-13-288 | 310 | 2376-5-788  | 410 | 3205-92-288 |

| Length<br>in Ft. | TONS       | Length<br>in Ft. | TONS        | Length<br>in Ft. | TONS         | Length<br>in Ft. | TONS         |
|------------------|------------|------------------|-------------|------------------|--------------|------------------|--------------|
| 40 FEET BEAM     |            |                  |             |                  |              |                  |              |
| 1                | 8-48       | 130              | 902-12      | 230              | 1753-18      | 330              | 2604-24      |
| 2                | 17-2       | 140              | 987-22      | 240              | 1838-28      | 340              | 2689-34      |
| 3                | 25-50      | 150              | 1072-32     | 250              | 1923-38      | 350              | 2774-44      |
| 4                | 34-4       | 160              | 1157-42     | 260              | 2008-48      | 360              | 2859-54      |
| 5                | 42-52      | 170              | 1242-52     | 270              | 2093-58      | 370              | 2944-64      |
| 6                | 51-6       | 180              | 1327-62     | 280              | 2178-68      | 380              | 3029-74      |
| 7                | 59-54      | 190              | 1412-72     | 290              | 2263-78      | 390              | 3114-84      |
| 8                | 68-8       | 200              | 1497-82     | 300              | 2348-88      | 400              | 3200-0       |
| 9                | 76-56      | 210              | 1582-92     | 310              | 2434-4       | 410              | 3285-10      |
| 120              | 817-2      | 220              | 1668-8      | 320              | 2519-14      | 420              | 3370-20      |
| 40.5 FEET BEAM   |            |                  |             |                  |              |                  |              |
| 1                | 8-58.125   | 130              | 922-19.2.3  | 230              | 1794-63.7.13 | 330              | 2667-14.2.13 |
| 2                | 17-42.25   | 140              | 1009-42.463 | 240              | 1881-86.963  | 340              | 2754-37.463  |
| 3                | 26-16.875  | 150              | 1096-65.713 | 250              | 1969-16.213  | 350              | 2841-60.713  |
| 4                | 34-84.5    | 160              | 1183-88.963 | 260              | 2056-39.463  | 360              | 2929-83.963  |
| 5                | 43-58.625  | 170              | 1271-18.213 | 270              | 2143-62.713  | 370              | 3016-13.213  |
| 6                | 52-32.75   | 180              | 1358-41.463 | 280              | 2230-85.963  | 380              | 3103-36.463  |
| 7                | 61-6.875   | 190              | 1445-64.137 | 290              | 2318-15.213  | 390              | 3190-59.713  |
| 8                | 69-75.0    | 200              | 1532-87.963 | 300              | 2405-38.463  | 400              | 3277-82.963  |
| 9                | 78-49.125  | 210              | 1620-17.213 | 310              | 2492-61.713  | 410              | 3365-12.213  |
| 120              | 834-89.963 | 220              | 1707-40.463 | 320              | 2579-84.963  | 420              | 3452-35.463  |
| 41 FEET BEAM     |            |                  |             |                  |              |                  |              |
| 1                | 8-88.5     | 130              | 942-40.7    | 230              | 1836-54.7    | 330              | 2730-68.7    |
| 2                | 17-83.0    | 140              | 1031-79.7   | 240              | 1925-93.7    | 340              | 2820-13.7    |
| 3                | 26-77.5    | 150              | 1121-24.7   | 250              | 2015-38.7    | 350              | 2909-52.7    |
| 4                | 35-72.0    | 160              | 1210-63.7   | 260              | 2104-77.7    | 360              | 2998-91.7    |
| 5                | 44-66.5    | 170              | 1300-8.7    | 270              | 2194-22.7    | 370              | 3088-36.7    |
| 6                | 53-61.0    | 180              | 1389-47.7   | 280              | 2283-61.7    | 380              | 3177-75.7    |
| 7                | 62-55.5    | 190              | 1478-86.7   | 290              | 2373-6.7     | 390              | 3267-20.7    |
| 8                | 71-50.0    | 200              | 1568-31.7   | 300              | 2462-45.7    | 400              | 3356-59.7    |
| 9                | 80-44.5    | 210              | 1657-70.7   | 310              | 2551-84.7    | 410              | 3446-4.7     |
| 120              | 853-1.7    | 220              | 1747-15.7   | 320              | 2641-29.7    | 420              | 3536-43.7    |
| 41.5 FEET BEAM   |            |                  |             |                  |              |                  |              |
| 1                | 9-15.125   | 130              | 962-76.238  | 230              | 1878-84.738  | 330              | 2794-93.238  |
| 2                | 18-30.25   | 140              | 1054-39.488 | 240              | 1970-47.988  | 340              | 2886-56.488  |
| 3                | 27-45.375  | 150              | 1146-2.738  | 250              | 2062-11.238  | 350              | 2978-19.738  |
| 4                | 36-60.5    | 160              | 1237-59.988 | 260              | 2153-68.488  | 360              | 3069-76.988  |
| 5                | 45-75.625  | 170              | 1329-23.238 | 270              | 2245-31.738  | 370              | 3161-40.238  |
| 6                | 54-90.75   | 180              | 1420-80.488 | 280              | 2336-88.988  | 380              | 3253-3.488   |
| 7                | 64-11.875  | 190              | 1512-43.738 | 290              | 2428-52.238  | 390              | 3344-60.738  |
| 8                | 73-27.0    | 200              | 1604-6.988  | 300              | 2520-15.488  | 400              | 3436-23.988  |
| 9                | 82-42.125  | 210              | 1695-64.238 | 310              | 2611-72.738  | 410              | 3527-81.238  |
| 120              | 871-18.988 | 220              | 1787-27.488 | 320              | 2703-35.988  | 420              | 3619-44.488  |



| Length<br>in Ft. | TONS       | Length<br>in Ft. | TONS        | Length<br>in Ft. | TONS         | Length<br>in Ft. | TONS        |
|------------------|------------|------------------|-------------|------------------|--------------|------------------|-------------|
| 42 FEET BEAM     |            |                  |             |                  |              |                  |             |
| 1                | 9-36       | 140              | 1077-15     | 250              | 2109-27      | 360              | 3141-39     |
| 2                | 18-72      | 150              | 1170-93     | 260              | 2203-11      | 370              | 3235-23     |
| 3                | 28-14      | 160              | 1264-77     | 270              | 2296-39      | 380              | 3329-7      |
| 4                | 37-50      | 170              | 1358-61     | 280              | 2390-73      | 390              | 3422-85     |
| 5                | 46-86      | 180              | 1452-45     | 290              | 2484-57      | 400              | 3516-69     |
| 6                | 56-28      | 190              | 1546-29     | 300              | 2578-41      | 410              | 3610-53     |
| 7                | 65-64      | 200              | 1640-13     | 310              | 2672-25      | 420              | 3704-37     |
| 8                | 75-6       | 210              | 1733-91     | 320              | 2766-9       | 430              | 3798-21     |
| 9                | 84-42      | 220              | 1827-75     | 330              | 2859-87      | 440              | 3892-5      |
| 120              | 889-47     | 230              | 1921-59     | 340              | 2953-71      | 450              | 3985-83     |
| 130              | 983-31     | 240              | 2015-43     | 350              | 3047-55      | 460              | 4079-67     |
| 42.5 FEET BEAM   |            |                  |             |                  |              |                  |             |
| 1                | 9-57-125   | 140              | 1100-7-813  | 250              | 2156-87-563  | 360              | 3213-73-513 |
| 2                | 19-20-25   | 150              | 1196-15-063 | 260              | 2253-0-813   | 370              | 3309-80-563 |
| 3                | 28-77-375  | 160              | 1292-22-313 | 270              | 2349-8-063   | 380              | 3405-87-813 |
| 4                | 38-40-5    | 170              | 1388-29-563 | 280              | 2445-15-313  | 390              | 3502-1-063  |
| 5                | 48-3-625   | 180              | 1484-36-813 | 290              | 2541-22-563  | 400              | 3598-8-313  |
| 6                | 57-60-75   | 190              | 1580-44-063 | 300              | 2637-29-813  | 410              | 3694-15-563 |
| 7                | 67-23-875  | 200              | 1676-51-313 | 310              | 2733-37-063  | 420              | 3790-22-813 |
| 8                | 76-81-0    | 210              | 1772-58-563 | 320              | 2829-44-313  | 430              | 3886-30-063 |
| 9                | 86-44-125  | 220              | 1868-65-813 | 330              | 2925-51-563  | 440              | 3982-37-813 |
| 120              | 907-87-313 | 230              | 1964-73-063 | 340              | 3021-58-813  | 450              | 4078-44-563 |
| 130              | 1004-0-563 | 240              | 2060-80-313 | 350              | 3117-66-063  | 460              | 4174-51-813 |
| 43 FEET BEAM     |            |                  |             |                  |              |                  |             |
| 1                | 9-78-5     | 140              | 1123-15-9   | 250              | 2203-2-9     | 360              | 3286-83-9   |
| 2                | 19-63-0    | 150              | 1221-48-9   | 260              | 2303-35-9    | 370              | 3385-22-9   |
| 3                | 29-47-5    | 160              | 1319-81-9   | 270              | 2401-68-9    | 380              | 3483-55-9   |
| 4                | 39-32-0    | 170              | 1418-20-9   | 280              | 2500-7-9     | 390              | 3581-88-9   |
| 5                | 49-16-5    | 180              | 1516-53-9   | 290              | 2598-40-9    | 400              | 3680-27-9   |
| 6                | 59-1-0     | 190              | 1614-86-9   | 300              | 2696-73-9    | 410              | 3778-60-9   |
| 7                | 68-79-5    | 200              | 1713-25-9   | 310              | 2795-12-9    | 420              | 3876-93-9   |
| 8                | 78-64-0    | 210              | 1811-58-9   | 320              | 2893-45-9    | 430              | 3975-32-9   |
| 9                | 88-48-5    | 220              | 1909-91-9   | 330              | 2991-78-9    | 440              | 4073-65-9   |
| 120              | 926-43-9   | 230              | 2008-30-9   | 340              | 3090-17-9    | 450              | 4172-4-9    |
| 130              | 1024-76-9  | 240              | 2106-63-9   | 350              | 3188-50-9    | 460              | 4270-37-9   |
| 43.5 FEET BEAM   |            |                  |             |                  |              |                  |             |
| 1                | 10-6-125   | 150              | 1090-55-125 | 260              | 21750-31-138 | 280              | 2555-51-138 |
| 2                | 20-12-25   | 160              | 1045-72-388 | 270              | 21850-82-388 | 290              | 2656-18-388 |
| 3                | 30-18-375  | 170              | 1146-39-638 | 280              | 21951-59-638 | 300              | 2758-79-638 |
| 4                | 40-24-5    | 180              | 1247-6-888  | 290              | 22052-26-888 | 310              | 2857-46-888 |
| 5                | 50-30-625  | 190              | 1347-68-138 | 300              | 22152-88-138 | 320              | 2958-14-138 |
| 6                | 60-36-75   | 200              | 1448-35-388 | 310              | 22253-55-388 | 330              | 3058-75-388 |
| 7                | 70-42-875  | 210              | 1549-2-638  | 320              | 22354-22-638 | 340              | 3159-42-638 |
| 8                | 80-49-0    | 220              | 1649-63-888 | 330              | 22454-83-888 | 350              | 3260-9-888  |

| Lgth.<br>in Ft.            | TONS        | Lgth.<br>in Ft. | TONS        | Lgth.<br>in Ft. | TONS        | Lgth.<br>in Ft. | TONS        |
|----------------------------|-------------|-----------------|-------------|-----------------|-------------|-----------------|-------------|
| 48·5 FEET BEAM (concluded) |             |                 |             |                 |             |                 |             |
| 360                        | 3360-71·138 | 390             | 3662-66·888 | 420             | 3964-62·638 | 450             | 4266-58·388 |
| 370                        | 3461-38·388 | 400             | 3763-34·138 | 430             | 4065-29·888 | 460             | 4367-25·638 |
| 380                        | 3562-5·638  | 410             | 3864-1·388  | 440             | 4165-91·138 | 470             | 4467-86·888 |
| 44 FEET BEAM               |             |                 |             |                 |             |                 |             |
| 1                          | 10-28       | 150             | 1272-76     | 260             | 2405-54     | 370             | 3538-32     |
| 2                          | 20-56       | 160             | 1375-74     | 270             | 2508-52     | 380             | 3641-30     |
| 3                          | 30-84       | 170             | 1478-72     | 280             | 2611-50     | 390             | 3744-28     |
| 4                          | 41-18       | 180             | 1581-70     | 290             | 2714-48     | 400             | 3847-26     |
| 5                          | 51-46       | 190             | 1684-68     | 300             | 2817-46     | 410             | 3950-24     |
| 6                          | 61-74       | 200             | 1787-66     | 310             | 2920-44     | 420             | 4053-22     |
| 7                          | 72-8        | 210             | 1890-64     | 320             | 3023-42     | 430             | 4156-20     |
| 8                          | 82-36       | 220             | 1993-62     | 330             | 3126-40     | 440             | 4259-18     |
| 9                          | 92-64       | 230             | 2096-60     | 340             | 3229-38     | 450             | 4362-16     |
| 130                        | 1066-80     | 240             | 2199-58     | 350             | 3332-36     | 460             | 4465-14     |
| 140                        | 1169-78     | 250             | 2302-56     | 360             | 3435-34     | 470             | 4568-12     |
| 44·5 FEET BEAM             |             |                 |             |                 |             |                 |             |
| 1                          | 10-50·125   | 150             | 1298-70·413 | 260             | 2457-38·163 | 370             | 3616-5·913  |
| 2                          | 21-6·25     | 160             | 1404-7·663  | 270             | 2562-69·413 | 380             | 3721-37·163 |
| 3                          | 31-56·375   | 170             | 1509-38·913 | 280             | 2668-6·663  | 390             | 3826-68·413 |
| 4                          | 42-12·5     | 180             | 1614-70·163 | 290             | 2773-37·913 | 400             | 3932-5·663  |
| 5                          | 52-62·625   | 190             | 1720-7·413  | 300             | 2878-69·163 | 410             | 4037-36·913 |
| 6                          | 63-18·75    | 200             | 1825-38·663 | 310             | 2984-6·413  | 420             | 4142-68·163 |
| 7                          | 73-68·875   | 210             | 1930-69·913 | 320             | 3089-37·663 | 430             | 4248-5·413  |
| 8                          | 84-25·0     | 220             | 2036-7·163  | 330             | 3194-68·913 | 440             | 4353-36·663 |
| 9                          | 94-75·125   | 230             | 2141-38·413 | 340             | 3300-6·163  | 450             | 4458-67·913 |
| 130                        | 1088-7·913  | 240             | 2246-69·663 | 350             | 3405-37·413 | 460             | 4564-5·163  |
| 140                        | 1193-39·163 | 250             | 2352-6·913  | 360             | 3510-68·663 | 470             | 4669-36·413 |
| 45 FEET BEAM               |             |                 |             |                 |             |                 |             |
| 1                          | 10-72·5     | 150             | 1324-81·5   | 260             | 2509-66·5   | 370             | 3694-51·5   |
| 2                          | 21-51·0     | 160             | 1432-54·5   | 270             | 2617-39·5   | 380             | 3802-24·5   |
| 3                          | 32-29·5     | 170             | 1540-27·5   | 280             | 2725-12·5   | 390             | 3909-91·5   |
| 4                          | 43-8·0      | 180             | 1648-0·5    | 290             | 2832-79·5   | 400             | 4017-64·5   |
| 5                          | 53-80·5     | 190             | 1755-67·5   | 300             | 2940-52·5   | 410             | 4125-37·5   |
| 6                          | 64-59·0     | 200             | 1863-40·5   | 310             | 3048-25·5   | 420             | 4233-10·5   |
| 7                          | 75-37·5     | 210             | 1971-13·5   | 320             | 3155-92·5   | 430             | 4340-77·5   |
| 8                          | 86-16·0     | 220             | 2078-80·5   | 330             | 3263-65·5   | 440             | 4448-50·5   |
| 9                          | 96-88·5     | 230             | 2186-53·5   | 340             | 3371-38·5   | 450             | 4556-23·5   |
| 130                        | 1109-41·5   | 240             | 2294-26·5   | 350             | 3479-11·5   | 460             | 4663-90·5   |
| 140                        | 1217-14·5   | 250             | 2401-93·5   | 360             | 3586-78·5   | 470             | 4771-63·5   |
| 45·5 FEET BEAM             |             |                 |             |                 |             |                 |             |
| 1                          | 11-1·125    | 4               | 44-4·5      | 7               | 77-7·875    | 130             | 130-87·338  |
| 2                          | 22-2·25     | 5               | 55-5·625    | 8               | 88-9·0      | 140             | 1241-4·588  |
| 3                          | 33-3·375    | 6               | 66-6·75     | 9               | 99-10·125   | 150             | 1351-15·838 |

## TONNAGE TABLES.

| Lgth.<br>in Ft.          | TONS        | Lgth.<br>in Ft. | TONS        | Lgth.<br>in Ft. | TONS        | Lgth.<br>in Ft. | TONS        |
|--------------------------|-------------|-----------------|-------------|-----------------|-------------|-----------------|-------------|
| 49 FEET BEAM (concluded) |             |                 |             |                 |             |                 |             |
| 330                      | 3839-4.3    | 380             | 4477-57.3   | 430             | 5116-16.3   | 480             | 5754-69.3   |
| 340                      | 3966-71.3   | 390             | 4605-30.3   | 440             | 5243-83.3   | 490             | 5882-42.3   |
| 350                      | 4094-44.3   | 400             | 4733-3.3    | 450             | 5371-56.3   | 500             | 6010-5.3    |
| 360                      | 4222-17.3   | 410             | 4860-70.3   | 460             | 5499-29.3   | 510             | 6137-72.3   |
| 370                      | 4349-84.3   | 420             | 4988-43.3   | 470             | 5627-2.3    | 520             | 6265-45.3   |
| 49.5 FEET BEAM           |             |                 |             |                 |             |                 |             |
| 1                        | 13-3.125    | 170             | 1828-53.038 | 290             | 3392-52.038 | 410             | 4956-51.038 |
| 2                        | 26-6.25     | 180             | 1958-84.288 | 300             | 3522-83.288 | 420             | 5086-82.288 |
| 3                        | 39-9.375    | 190             | 2089-21.538 | 310             | 3653-20.538 | 430             | 5217-19.538 |
| 4                        | 52-12.5     | 200             | 2219-52.788 | 320             | 3783-51.788 | 440             | 5347-50.788 |
| 5                        | 65-15.625   | 210             | 2349-84.038 | 330             | 3913-83.038 | 450             | 5477-82.038 |
| 6                        | 78-18.75    | 220             | 2480-21.288 | 340             | 4044-20.288 | 460             | 5608-19.288 |
| 7                        | 91-21.875   | 230             | 2610-52.538 | 350             | 4174-51.538 | 470             | 5738-50.538 |
| 8                        | 104-25.0    | 240             | 2740-83.788 | 360             | 4304-82.788 | 480             | 5868-81.788 |
| 9                        | 117-28.125  | 250             | 2871-21.038 | 370             | 4435-20.038 | 490             | 5999-19.038 |
| 140                      | 1437-53.288 | 260             | 3001-52.288 | 380             | 4565-51.288 | 500             | 6129-50.288 |
| 150                      | 1567-84.538 | 270             | 3131-83.538 | 390             | 4695-82.538 | 510             | 6259-81.538 |
| 160                      | 1698-21.788 | 280             | 3262-20.788 | 400             | 4826-19.788 | 520             | 6390-18.788 |
| 50 FEET BEAM             |             |                 |             |                 |             |                 |             |
| 1                        | 13-28       | 180             | 1994-64     | 300             | 3590-40     | 420             | 5186-16     |
| 2                        | 26-56       | 190             | 2127-62     | 310             | 3723-38     | 430             | 5319-14     |
| 3                        | 39-84       | 200             | 2260-60     | 320             | 3856-36     | 440             | 5452-12     |
| 4                        | 53-18       | 210             | 2393-58     | 330             | 3989-34     | 450             | 5585-10     |
| 5                        | 66-46       | 220             | 2526-56     | 340             | 4122-32     | 460             | 5718-8      |
| 6                        | 79-74       | 230             | 2659-54     | 350             | 4255-30     | 470             | 5861-6      |
| 7                        | 93-8        | 240             | 2792-52     | 360             | 4388-28     | 480             | 5984-4      |
| 8                        | 106-36      | 250             | 2925-50     | 370             | 4521-26     | 490             | 6117-2      |
| 9                        | 119-64      | 260             | 3058-48     | 380             | 4654-24     | 500             | 6250-0      |
| 150                      | 1595-70     | 270             | 3191-46     | 390             | 4787-22     | 510             | 6382-92     |
| 160                      | 1728-68     | 280             | 3324-44     | 400             | 4920-20     | 520             | 6515-90     |
| 170                      | 1861-66     | 290             | 3457-42     | 410             | 5053-18     | 530             | 6648-88     |
| 50.5 FEET BEAM           |             |                 |             |                 |             |                 |             |
| 1                        | 13-53.125   | 180             | 2030-66.213 | 300             | 3658-49.213 | 420             | 5286-32.213 |
| 2                        | 27-12.25    | 190             | 2166-33.463 | 310             | 3794-16.463 | 430             | 5421-93.463 |
| 3                        | 40-65.375   | 200             | 2302-0.713  | 320             | 3929-77.713 | 440             | 5557-60.713 |
| 4                        | 54-24.5     | 210             | 2437-61.963 | 330             | 4065-44.963 | 450             | 5693-27.963 |
| 5                        | 67-77.625   | 220             | 2573-29.213 | 340             | 4201-12.213 | 460             | 5828-89.213 |
| 6                        | 81-36.75    | 230             | 2708-90.463 | 350             | 4336-73.463 | 470             | 5964-56.463 |
| 7                        | 94-89.875   | 240             | 2844-57.713 | 360             | 4472-40.713 | 480             | 6100-23.713 |
| 8                        | 108-49.0    | 250             | 2980-24.963 | 370             | 4608-7.963  | 490             | 6235-84.963 |
| 9                        | 122-8.125   | 260             | 3115-86.213 | 380             | 4743-69.213 | 500             | 6371-52.213 |
| 150                      | 1623-70.463 | 270             | 3251-53.463 | 390             | 4879-36.463 | 510             | 6507-19.463 |
| 160                      | 1759-37.713 | 280             | 3387-20.713 | 400             | 5015-3.713  | 520             | 6642-80.713 |
| 170                      | 1895-4.963  | 290             | 3522-81.963 | 410             | 5150-64.963 | 530             | 6778-47.963 |

## BOARD OF TRADE REGULATIONS FOR SHIPS.

## PASSENGER CERTIFICATES.

THESE certificates are granted as follows :—

Form survey 1 (sea-going) is given for foreign-going steamers.

" " 2 " " " home trade passenger steamers.

Form survey 3 (excursion) is given for steamers plying along the coast during daylight between any of the places mentioned in column 1 of the following table of limits and the places set opposite to them in column 4 of the same table.

Form survey 4 (river) is given for steamers plying between any of the places mentioned in column 1 of the table and the places set opposite to them in column 3.

Form survey 5 (rivers and lakes) is given for steamers plying in the smooth-water limits lying between the places mentioned in column 1 and the places set opposite to them in column 2.

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES.

| COL. 1.<br>Name of Port | Form Survey 5.<br>COL. 2.<br>Smooth Water<br>Limits | Form Survey 4.<br>COL. 3.<br>Partially Smooth<br>Water Limits    | Form Survey 3.<br>COL. 4<br>Excursion Limits |
|-------------------------|---|--|--|
| ABERDEEN .              | All within Aber-<br>deen                            | Nil . . .  | Nil  |
| BRISTOL .               | Portishead .  | The Holmes . . .   | Tenby or Ilfra-<br>combe                     |
| BOWNESS .               | Anywhere on<br>the Lake                             | Nil . . .  | Nil  |
| BOSTON .                | Above the El-<br>bow Buoy                           | The Lynn Well<br>Light Ship                                      | Grimsby or Wells                             |
| BERWICK (N.)            | Nil . . .   | Within a line from<br>Berwick to An-<br>struther                 | See Leith                                    |
| BELFAST .               | Hollywood .   | Within Carrick-<br>fergus and Bangor,<br>and to Grooms-<br>point | Larne and the<br>South Rock<br>Lighthouse    |
| BARROW .                | Walney Islands                                      | Places within More-<br>cambe and Lan-<br>caster Bays             | Liverpool                                    |
| BRIGG (HULL)            | Same as Hull .                                      | Nil . . .  | Nil  |

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES (continued).

| COL. 1.<br>Name of Port         | Form Survey 5.<br>COL. 2.<br>Smooth Water<br>Limits | Form Survey 4.<br>COL. 3.<br>Partially Smooth<br>Water Limits | Form Survey 3<br>COL. 4.<br>Excursion Limits        |
|---------------------------------|---|---|---|
| CARLISLE .                      | Above Carlisle                                      | Dumfries and Southernness .                                   | Whitehaven or Kirkcudbright                         |
| CARDIFF .                       | Penarth .   | The Holmes .  | Tenby   |
| CARNARVON .                     | Inside Carnarvon Bar and Priestholm Island          | Conway .  | Nil   |
| CONWAY .                        | On the river Conway                                 | Any place between Priestholm Island and Carnarvon Bar         | Liverpool   |
| CORK .                          | A line from Camden to Carlisle Forts                | A line from Cork Head to Poor Head                            | Ybughal or Kinsale                                  |
| CAMPBELTOWN                     | In the Harbour                                      | Nil . . .   | See Glasgow   |
| DARTMOUTH .                     | River Dart .  | Nil . . .   | Inside a line from Start Point to Portland Bill     |
| DOVER .                         | Nil . . .   | Nil . . .   | Rye or Margate                                      |
| DUNDEE .                        | New Railway Bridge at Dundee                        | Broughty Castle .   | Montrose or Fife-ness                               |
| DROGHEDA .                      | Nil . . .   | Nil . . .   | Dundalk and Balbriggan                              |
| DUNDALK .                       | Nil . . .   | Nil . . .   | Drogheda and Kilkeel                                |
| DUBLIN .                        | Nil . . .   | Kingstown .   | Howth or Wicklow                                    |
| DOUGLAS (I.M.)                  | Nil . . .   | Nil . . .   | See Liverpool                                       |
| FLEETWOOD .                     | All above the Upper Light-house                     | Places within Morecambe and Lancaster Bays                    | Liverpool   |
| FALMOUTH .                      | A line from Zose Point to Pen-dennis Point          | For special St. 4a Declarations, Black Head or Gull Rock      | Lizard or Start Points                              |
| FOLKESTONE .                    | Nil . . .   | Nil . . .   | Rye or Margate                                      |
| GALWAY .                        | —   | Kinvarra .  | Kilkerrin or Liscannon Bays, inside the Arran Isles |
| GLOUCESTER .                    | Sharpness Point                                     | Bristol, Newport, or any place above the Holmes               | Tenby or Ilfracombe                                 |
| GAINS-<br>BOROUGH (see<br>HULL) | —   | —   | —   |

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES (continued).

| COL. 1.<br>Name of Port | Form Survey 5.<br>COL. 2.<br>Smooth Water<br>Limits | Form Survey 4.<br>COL. 3.<br>Partially Smooth<br>Water Limits   | Form Survey 3.<br>COL. 4.<br>Excursion Limits   |
|-------------------------|---|---|---|
| GLASGOW                 | Dunoon . . .  | Cumbray and Skipness  | Inverness per Crinan and Caledonian Canals, and to a line from Ayr to Campbeltown, inside the Island of Arran |
| GRIMSBY                 | Hull and New Holland                                | Grimsby . . .   | Scarborough or Lynn   |
| GOOLE . . .             | Hull . . .  | Grimsby . . .   | See Hull  |
| HARTLEPOOL.             | Nil . . .   | Nil . . .   | Newcastle or Scarborough  |
| HULL . . .              | Hull and New Holland                                | Grimsby . . .   | Lynn or Scarborough   |
| INVERNESS               | Inwards to Fort William                             | Outwards to Lough Cromarty, Nairn, and Three Kings; inwards to South End of Loch Linnhe and West End of Sound of Mull | Nil   |
| IPSWICH                 | Languard Fort                                       | Walton-on-the-Naze  | Orford Ness and Walton-on-the-Naze  |
| LANCASTER               | Lancaster Harbour                                   | Places within Morecambe and Lancaster Bays  | Whitehaven or Liverpool   |
| LEITH . . .             | Queensferry .                                       | North Berwick and Anstruther  | Fife Ness to St. Abb's Head   |
| LIMERICK                | Foynes . . .  | Kilcradine Light-house  | Loophead and Tralee   |
| LITTLEHAMPTON           | Little Arun, above Littlehampton Pier               | Nil . . .   | Nil   |
| LONDONDERRY             | Moville . . .                                       | Nil . . .   | Port Rush and Malinhead   |
| LOWESTOFT               | Nil . . .   | Nil . . .   | Cromer or Aldborough  |
| LIVERPOOL               | The Rock Lighthouse                                 | The Bell Buoy and N.W. Light Ship   | Any place within the Menai Straits or to Fleetwood  |
| LONDON . .              | Gravesend . .                                       | A line from St. Osyth Point to Fore Ness  | Harwich or Dover  |

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES (continued).

| COL. 1.<br>Name of Port            | Form Survey 5.<br>COL. 2.<br>Smooth Water<br>Limits       | Form Survey 4.<br>COL. 3.<br>Partially Smooth<br>Water Limits  | Form Survey 3.<br>COL. 4.<br>Excursion Limits |
|------------------------------------|---|--|---|
| MILFORD                            | Dale Bay  | St. Anne's Light-house   | Swansea or St. David's Head                   |
| NORWICH                            | Yarmouth  | Nil  | Nil   |
| NEATH                              | Nil   | Swansea  | Tenby   |
| NEWRY                              | Warren Point  | Carlingford and Whitehouse Point   | Dundalk and Killeel                           |
| NEWCASTLE, NORTH AND SOUTH SHIELDS | Tynemouth Bar   | Nil  | Berwick or Scarborough                        |
| PADSTOW                            | Padstow Harbour, above a line from Gun Point to Brea Hill | A line from Stepper Point to Trebetherick Point  | —   |
| PENZANCE                           | —   | For special St. 4a Declarations, a line drawn from Mousehole to the Eastern Point of St. Michael's Mount   | Cape Cornwall or Falmouth                     |
| PORTSMOUTH                         | Inside Portsmouth Harbour                                 | St. Helen's and the Needles, within the Isle of Wight, and to Langston Harbour. For small launches not carrying boats: <i>In summer</i> , a line from Ryde to Langston Harbour, inside the Isle of Wight, to Hurst Castle; <i>in winter</i> , Spithead | Weymouth West to Brighton East                |
| PRESTON                            | Lytham  | Nil  | Barrow or Liverpool                           |
| POOLE                              | In the Harbour  | Nil  | Weymouth or Portsmouth                        |
| PLYMOUTH                           | Inside Drake's Island                                     | The Breakwater   | Lizard or Start Points                        |
| ROCHESTER                          | Sheerness and to Whitstable, inside Sheppey               | The Nore and Margate ( <i>see</i> London)  | Dover or Harwich                              |
| SWANSEA                            | Nil   | Neath  | Ilfracombe or Milford                         |

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES (concluded).

| COL. 1.<br>Name of Port  | Form Survey 5.<br>COL. 2.<br>Smooth Water<br>Limits | Form Survey 4.<br>COL. 3.<br>Partially Smooth<br>Water Limits  | Form Survey 3.<br>COL. 4.<br>Excursion Limits |
|--------------------------|---|--|---|
| SUNDERLAND .             | Sunderland Bar                                      | Nil . . .  | Scarborough or<br>Berwick                     |
| STOCKTON .               | Nil . . .   | Nil . . .  | Bridlington or<br>Newcastle                   |
| SOUTHAMPTON              | Calshot . .   | St. Helen's and the<br>Needles, inside the<br>Isle of Wight, and<br>to Langston Har-<br>bour<br>See Portsmouth for<br>limits for small<br>launches | Weymouth or<br>Brighton                       |
| SCARBOROUGH              | Nil . . .   | Nil . . .  | Newcastle or Hull                             |
| TEIGNMOUTH.              | Teignmouth<br>Harbour                               | Nil . . .  | Portland Bill or<br>Start Point               |
| WATERFORD .              | Passage . .   | Dunmore . .  | Dungarvan and<br>Cringley                     |
| WIGTOWN .                | Nil . . .   | Within Wigtown<br>Bay  | Mull of Galloway<br>or Southernness           |
| WISBEACH<br>(see BOSTON) | —   | —  | —   |
| WEYMOUTH .               | Nil . . .   | Portland Harbour .   | Portsmouth or<br>Start Point                  |
| WHITBY .                 | Nil . . .   | Nil . . .  | Bridlington or<br>Newcastle                   |

## EXAMINATION OF HULLS.

Passenger vessels are to be surveyed once a year.

New steamships are to be surveyed before the hull is complete, and before the paint and cement are put on, as well as when complete.

Collision water-tight bulkheads must be fitted in all sea-going steamers.

Screw tunnels of all iron passenger steam vessels should be made of iron and made water-tight.

A water-tight door should be fitted at the fore end of the tunnel, arrangements being made so that it can be opened from the upper or main deck; and if there are man-holes in the floor they must be made water-tight, and proper arrangements made so as to let the water off the floor of the tunnel.

The maximum period for which a steamer's certificate of registry is granted is 12 months.



## BOATS.

Sea-going ships are to be provided, according to their tonnage, with boats, duly supplied with all requisites for use, and not fewer in number nor less in cubical contents than the boats—the number and cubical contents of which are specified in the following table—for the class to which the ship belongs.

Sea-going ships carrying more than 10 passengers must be provided, in addition to the boats hereinbefore mentioned, with a life boat, unless one of the boats heretofore required is rendered buoyant after the manner of a life boat.

| TABLE OF THE DIMENSIONS OF BOATS REQUIRED TO BE CARRIED BY PASSENGER STEAMERS. |                 |            |         |         |                  |                 |            |         |         |                  |  |  |
|--|-----------------|------------|---------|---------|------------------|-----------------|------------|---------|---------|------------------|--|--|
| Number of Tons Register  | Either          |            |         |         |                  |                 | Or         |         |         |                  |  |  |
|  | Number of Boats | Dimensions |         |         | Cubical Contents | Number of Boats | Dimensions |         |         | Cubical Contents |  |  |
|  |                 | Length     | Breadth | Depth   |                  |                 | Length     | Breadth | Depth   |                  |  |  |
| 1,000 and upwards  |                 | ft. in.    | t. in.  | ft. in. | cub. ft.         |                 | ft. in.    | ft. in. | ft. in. | cub. ft.         |  |  |
|  | 1               | 18 0       | 5 6     | 2 3     | 133·7            | 1               | 18 0       | 5 6     | 2 3     | 133·7            |  |  |
|  | 2               | 24 0       | 5 6     | 2 6     | 396·0            | 2               | 24 0       | 5 6     | 2 6     | 396·0            |  |  |
|  | 1               | 27 0       | 8 6     | 3 8     | 504·9            | 2               | 22 0       | 5 6     | 2 6     | 363·0            |  |  |
|  |                 |            |         |         | 1,034·6          |                 |            |         |         | 892·7            |  |  |
|  | 2 Life          | 28 0       | 8 6     | 3 6     | 999·6            | 2 Life          | 28 0       | 8 6     | 3 6     | 999·6            |  |  |
|  | 6 Boats of      |            |         |         | 2,034·2          | 7 Boats of      |            |         |         | 1,892·3          |  |  |
| 800 to 1,000   | 1               | 18 0       | 5 6     | 2 3     | 133·7            | 1               | 18 0       | 5 6     | 2 3     | 133·7            |  |  |
|  | 2               | 26 0       | 6 6     | 2 8     | 540·8            | 2               | 24 0       | 5 6     | 2 6     | 540·8            |  |  |
|  | 1 Life          | 26 0       | 8 0     | 3 8     | 457·6            | 2               | 22 0       | 5 6     | 2 6     | 363·0            |  |  |
|  | 4 Boats of      |            |         |         | 1,132·1          | 5 Boats of      |            |         |         | 1,087·5          |  |  |
| 500 to 800   | 1               | 18 0       | 5 6     | 2 3     | 133·7            | 1               | 18 0       | 5 6     | 2 3     | 133·7            |  |  |
|  | 2               | 24 0       | 5 6     | 2 6     | 396·0            | 2               | 24 0       | 5 6     | 2 6     | 396·0            |  |  |
|  | 1 Life          | 26 0       | 8 0     | 3 8     | 457·6            | 2               | 22 0       | 5 6     | 2 6     | 363·0            |  |  |
|  | 4 Boats of      |            |         |         | 987·3            | 5 Boats of      |            |         |         | 892·7            |  |  |
| 380 to 500   | 1               | 16 0       | 5 6     | 2 3     | 118·8            | 1               | 16 0       | 5 6     | 2 3     | 118·8            |  |  |
|  | 2               | 24 0       | 5 6     | 2 6     | 396·0            | 2               | 24 0       | 5 6     | 2 6     | 396·0            |  |  |
|  | 1 Life          | 25 0       | 7 0     | 3 6     | 367·5            | 2               | 22 0       | 5 6     | 2 6     | 363·0            |  |  |
|  | 4 Boats of      |            |         |         | 882·3            | 5 Boats of      |            |         |         | 877·8            |  |  |

TABLE OF THE DIMENSIONS OF BOATS REQUIRED TO BE CARRIED BY PASSENGER STEAMERS (concluded).

| Number of Tons Register   | Either          |            |         |         |                  | Or  |            |         |         |                  |
|---|-----------------|------------|---------|---------|------------------|---|------------|---------|---------|------------------|
|   | Number of Boats | Dimensions |         |         | Cubical Contents | Number of Boats   | Dimensions |         |         | Cubical Contents |
|   |                 | Length     | Breadth | Depth   |                  |   | Length     | Breadth | Depth   |                  |
|   |                 | ft. in.    | ft. in. | ft. in. | cub. ft.         |   | ft. in.    | ft. in. | ft. in. | cub. ft.         |
| 240 to 360  | 1               | 16 0       | 5 6     | 2 3     | 118·8            | 1   | 16 0       | 5 6     | 2 3     | 118·8            |
|   | 1               | 22 0       | 5 6     | 2 5     | 175·4            | 1   | 22 0       | 5 6     | 2 5     | 175·4            |
|   | 1 Life          | 22 0       | 6 6     | 3 3     | 278·9            | 2   | 22 0       | 5 6     | 2 6     | 363·0            |
| 240 to 260  | 3 Boats of      |            |         |         | 573·1            | 4 Boats of  |            |         |         | 657·2            |
| 120 to 240  | 1               | 14 0       | 5 0     | 2 2     | 91·0             | 1   | 14 0       | 5 0     | 2 2     | 91·0             |
|   | 1 Life          | 20 0       | 6 0     | 3 0     | 216·0            | 2   | 22 0       | 5 6     | 2 6     | 363·0            |
|   | 2 Boats of      |            |         |         | 307·0            | 3 Boats of  |            |         |         | 454·0            |
| 60 to 120   | 1               | 14 0       | 5 0     | 2 2     | 91·0             | 1   | 14 0       | 5 0     | 2 2     | 91·0             |
|   | 1 Life          | 16 0       | 5 6     | 2 9     | 145·2            | 2   | 18 0       | 5 6     | 2 4     | 277·2            |
|   | 2 Boats of      |            |         |         | 236·2            | 3 Boats of  |            |         |         | 368·2            |
| Under 60  | 1 Life          | 14 0       | 5 0     | 2 2     | 91·0             |   |            |         |         |                  |
| If the number of boats in this column are carried, one of them must be a launch of at least the capacity named. No steam life-boat will be permitted. |                 |            |         |         |                  | If the number of boats in this column are carried, their cubical contents (equal in the aggregate to the cubical contents required) may be spread in any way over the whole number of boats. The life boat or life boats must be the largest boats. |            |         |         |                  |

If owners wish to carry a fewer number of boats, or wish to substitute rafts, &c., application must be made to the Board of Trade.

To ascertain the cubical contents of a boat, take the length and breadth outside and the depth inside, multiply them into each other, and then that product by the factor '6. The result will be assumed to be the cubical contents.

An efficient life boat is deemed capable of carrying one adult for every 10 cubic feet of her capacity.

A life boat must have at least  $1\frac{1}{2}$  cubic feet of air-tight compartments for every 10 feet of her cubical contents.

Zinc must not be used in the construction of a life boat.

## LIFE BUOYS.

A life jacket or belt to be supplied for each of the oarsmen, and one for the coxswain, of each life boat.

Every life jacket or belt must be capable of floating in water for 24 hours with 23 lbs. of iron suspended from it; and each life jacket, in which the cork must be exposed and have a canvas back and straps only, should weigh 5 lbs. when dry.

All cork life buoys should be built of solid cork, and must be capable of floating for 24 hours in water with 32 lbs. of iron suspended from them. If not made of cork they must be capable of floating in water for 24 hours with 40 lbs. of iron suspended from them.

No contrivance will be passed as a life buoy that requires inflation before use.

## PUMPS, SLUICE VALVES, STEERING GEAR, ETC.

There must be in each compartment a pump of sufficient size which can be worked from the upper deck.

There must be a valve or cock fitted at the bottom of each water-tight bulkhead, which can be opened from the upper deck, and also a sounding tube to each compartment.

Pipes connected with pumps, worked by the engines, are also to be carried through the bulkheads into the compartments fore and aft of the engine room; so that each compartment can be pumped out separately by the engines as well as by the deck pumps.

A spare tiller, relieving tackle, &c., should be carried in all sea-going steamers.

Rudder pendants should also be secured to the back of the rudder.

A deep-sea lead-line of at least 120 fathoms, a lead of at least 28 lbs. weight and a suitable reel, together with at least two hand lead-lines of 25 fathoms each, and leads of at least 7 lbs. each, should be supplied to all foreign-going steamers.

In home-trade steamers two hand lead-lines of 25 fathoms each, and leads of 7 lbs. each, must be supplied.

For a first-class certificate of registry (i.e. 12 months) double the number of leads and lines must be supplied.

Lead lines are usually marked as follows:—

|              |   |
|--------------|---|
| At 2 fathoms | a piece of leather split into two strips. |
| „ 3          | „ „ „ three strips.                       |
| „ 5          | „ „ white bunting.                        |
| „ 7          | „ „ red bunting.                          |
| „ 10         | „ „ leather with a hole.                  |
| „ 13         | „ „ blue bunting.                         |
| „ 15         | „ „ white bunting.                        |
| „ 17         | „ „ red bunting.                          |
| „ 20         | „ a strand with two knots tied in it.     |

## DISTRESS SIGNALS.

The signals required are 12 blue lights (or 6 blue lights and 6 of Holmes's patent storm and danger signal lights), 12 rockets, each containing 16 ozs. of composition, and one gun of at least  $3\frac{1}{2}$  ins. the bore, or one mortar of  $5\frac{1}{2}$  ins., with ammunition for 12 charges, or, in the case of foreign sea-going passenger ships, 24 charges. Each charge must contain 16 ozs. of pebble or bean powder in a flannel bag. An air-tight copper magazine, rammers, sponges, wads, priming wires, friction tubes, powder flasks, with fine powder for priming, and means of firing and withdrawing charges, should be provided.

Rocket lockers should not be air-tight.

## FIRE HOSE.

A fire hose adapted for extinguishing fire in any part of the ship, and capable of being connected with the engines of the ship, or with the donkey engine if it can be worked from the main boiler, should be supplied.

## PASSENGER ACCOMMODATION.

*Passengers in Foreign-going Steamers.*

The upper weather deck, and the upper surface of the poop, forecastle, and spar deck, are never to be included in the measurements for passengers; nor are the poop, round house, or deck house to be measured for passengers, unless they form part of the permanent structure of the vessel.

Foreign-going steamships carrying passengers are to be measured as follows:—

*Saloon or 1st Class.*—The number of fixed berths or sofas that are fitted determine the number of passengers to be allowed.

*2nd Class.*—The number is determined in the same way as the 1st class.

*3rd Class.*—The number may be determined in like manner if berths are fitted; if not, the net area of the deck, multiplied by the height between decks and the product divided by 72, gives the number to be allowed. The breadth of the deck is taken inside the water-way, or at the greatest tumble-home of the side, if there is any.

When cargo, stores, &c., are carried in the space measured for passengers, one passenger is to be deducted for every 12 superficial feet of deck space so occupied.

*Passengers in Home-Trade Sea-going Steamers.*

Fore-cabin passengers include all passengers except those entered as after-cabin or saloon passengers in the way bill.

The number of passengers allowed to be carried in sea-going home-trade steamers is ascertained as follows :—

The clear area of the deck in square feet is divided by nine; the quotient is the number allowed to be carried on deck in summer. Passengers in home-trade steamers are allowed to be carried on the main and lower decks only.

The breadths of the deck are taken from inside the gutter water-way, or the inside edge of the raised covering-board, or inside edge of the rail, if the bulwarks tumble home farther than the inside edge of the water-way or covering-board.

In cases where adequate shelter is not provided for deck passengers the whole number of passengers must not exceed one-fourth of the number representing the gross tonnage, with the addition of the number of after-cabin passengers, calculated as before.

Where cargo, cattle, &c., are carried in the space measured for passengers in home-trade passenger steamers, the following deductions are to be made :—

For every square yard of space measured for passengers occupied by cattle or other animals, or by cargo or other articles, one passenger is to be deducted.

If, however, the whole number so to be deducted on account of cattle or cargo carried on deck equals or exceeds the original number of passengers due to the deck space, so that no passengers are carried on deck, it may be covered with cattle or cargo, without any reduction on that account in the number of passengers carried in the cabins.

Between the 31st of October and the 1st of April the number of passengers which, according to the preceding rules, are allowed to be carried on deck in summer are to be reduced one-third, unless there is accommodation below, or in properly constructed cabins on deck, for half the full complement of passengers. This reduction not to be made in the case of foreign-going steamships.

One-third, however, of the space on deck measured for passengers may be occupied by cargo and cattle, without any reduction of the winter number of passengers.

The number of passengers to be carried in the after-cabins is determined by the number of berths or sofas; to which add the number due to the space on deck appropriated to the saloon passengers, and the sum will be the *total* number of after-cabin passengers allowed to be carried.

The floor space of saloons, cabins, state-rooms, and passages must not be measured, unless in saloons and cabins in which berths are not fitted; then the clear available space is to be measured, and one passenger allowed for every 9 square feet. When sofas or seats are fitted the measurements are to be taken from the backs of the said sofas or seats.

The number of fore-cabin passengers is obtained in the same way as the after-cabin number. The total number of passengers must not exceed the number denoting the gross register tonnage of the vessel.

When there are deck-houses, and only narrow spaces between the sides of the deck-houses and the bulwarks, such narrow spaces are not to be measured for passengers.

#### *Passengers in Excursion Steamers.*

For steamers used in excursions the rules for calculating the number of passengers are the same as in sea-going home-trade steamers, except that if application is made for an excursion certificate for short distances along the coast during daylight, the number, originally calculated at 9 superficial feet to each passenger, should it exceed the gross tonnage of the vessel, need not be diminished so as to bring down that number.

Where cargo, cattle, &c., are carried in the space measured for passengers in excursion steamers, one passenger is to be deducted for every square yard of space, measured for passengers, occupied by cattle, cargo, &c.

#### *Passengers in River Steamers.*

The measurements are to be made in the same manner as in home-trade sea-going steamers, except that after-saloons only are to be included.

There will be no distinction between fore- and after-cabin passengers.

River steamers are divided into those which ply on waters part of which only are smooth, and those which ply exclusively on smooth water.

Taking this division—

For steamers which ply in partially smooth water, divide the number of superficial feet on deck, obtained as before, by six, and the clear space in the after-saloon by nine, and the sum of these quotients will be the number of passengers allowed.

In the last-mentioned class of steamers one and a half passenger is to be deducted for every square yard of space measured for passengers occupied by cattle, cargo, &c.

A reduction is to be made during the winter months, in precisely the same manner as in home-trade sea-going steamers.

These vessels are to be provided with a fore-sail and jib bent, a suitable anchor and cable, a compass, a regulation life-boat, one dozen life buoys, and two safety valves on each boiler.

For smooth-water steamers divide the number of superficial feet on deck, obtained as before, by three, and the clear space in the after-saloon by nine, and the sum of these quotients is the number of passengers allowed.

Three passengers are to be deducted for every square yard of space measured for passengers occupied by cattle, cargo, &c.

No reduction to be made in winter months.

### *Crew Space.*

Every space occupied by the crew shall contain 72 cubic feet, and 12 superficial feet of surface for each seaman.

For every 20 men there should be two privies.

In measuring the clear area of deck in crew space, beds, bunks, or sleeping berths are not to be deducted as encumbrances, but in cabins there should not be less than 12 square feet per man exclusive of the bunk.

To compute the cubic capacity of the crew space, multiply the clear area of the floor space by the height from deck to deck at the middle line; the product will be the cubic capacity of the crew space. Divide the cubic capacity thus obtained by 72, and the quotient will be the number of men the place is to accommodate, provided that there is sufficient area of deck, as before computed.

Under the Merchant Shipping Act of 1867 the tonnage of all the places for the berthing of seamen and apprentices, and appropriated to their use, may be deducted from the register tonnage of the ship, provided that the number the crew space will accommodate is cut in or painted on or over the door or hatchway leading to such place; and also cut in on one of the beams in the inside of such crew space.

### *Minimum Dimensions of Ships' Lanterns.*

The back and sides must not be less than 9 ins., and the height inside not less than 11 ins. The lens must not be less than 5 ins. in height, and if it is to be used as a side light the lens must not be less than  $\frac{1}{3}$  of a circle, the chord of the arc made by the lens not being less than 8 ins.

ENGLISH WEIGHTS AND MEASURES.

AVOIRDUPOIS WEIGHT.

| Drams  | Ozs.  | Lbs.     | Qrs.     | Cwts.    | Ton       | Grammes  |
|--------|-------|----------|----------|----------|-----------|----------|
| 1      | ·0625 | ·0039063 | ·0001395 | ·0000349 | ·00000174 | 1·771846 |
| 16     | = 1   | ·0625    | ·0022321 | ·000558  | ·00002784 | 28·34954 |
| 256    | 16    | = 1      | ·0357143 | ·0089285 | ·00044643 | 453·5927 |
| 7168   | 448   | 28       | = 1      | ·25      | ·0125     | 12700·59 |
| 28672  | 1792  | 112      | 4        | = 1      | ·05       | 50802·58 |
| 573440 | 35840 | 2240     | 80       | 20       | = 1       | 1016048  |

A stone of iron, coal, &c. = 14 lbs.

TROY WEIGHT.

| Avoir. Drs.       | Grains | Dwts.    | Ozs.     | Lbs.     | Grammes  |
|-------------------|--------|----------|----------|----------|----------|
| 32 ÷ 875          | = 1    | ·0416667 | ·0020833 | ·0001736 | ·0648    |
| 768 ÷ 875         | 24     | = 1      | ·05      | ·0041667 | 1·5552   |
| 17 + (97 ÷ 175)   | 480    | 20       | = 1      | ·0833333 | 31·1035  |
| 210 + (114 ÷ 175) | 5760   | 240      | 12       | = 1      | 373·2420 |

175 lbs. Troy = 144 lbs. Avoir.

175 oz. Troy = 192 oz. Avoir.

Avoir. lbs. × 1·21527 = lbs. Troy.

Troy lbs. × ·823 = Avoir. lbs.

Avoir. lbs. × ·00898 = cwts.

Avoir. lbs. × ·000447 = tons.

LINEAL MEASURE.

| Inches | Feet   | Yards  | Faths.  | Poles   | Furls.  | Mile    | Metres  |
|--------|--------|--------|---------|---------|---------|---------|---------|
| 1      | ·08333 | ·02778 | ·013889 | ·005051 | ·000126 | ·000016 | ·0254   |
| 12     | = 1    | ·33333 | ·166667 | ·060606 | ·001515 | ·000189 | ·304797 |
| 36     | 3      | = 1    | ·5      | ·181818 | ·004545 | ·000568 | ·914392 |
| 72     | 6      | 2      | = 1     | ·363636 | ·009091 | ·001136 | 1·82878 |
| 198    | 16½    | 5½     | 2½      | = 1     | ·025    | ·003125 | 5·02915 |
| 7920   | 660    | 220    | 110     | 40      | = 1     | ·125    | 201·166 |
| 63360  | 5280   | 1760   | 880     | 320     | 8       | = 1     | 1609·33 |

The palm = 3 in.

The hand = 4 in.

The span = 9 in.

The cubit = 18 in.

The common military pace = 30 in.

An itinerary pace = 5 feet.

A cable's length = 120 fathoms.

A league = 3 miles.

LAND MEASURE (LINEAL).

| Inches | Links    | Feet     | Yards    | Chains   | Mile     | Metres  |
|--------|----------|----------|----------|----------|----------|---------|
| 1      | ·1261261 | ·0833333 | ·0277778 | ·0012626 | ·0000158 | ·0254   |
| 72½    | = 1      | ·6666667 | ·2222222 | ·01      | ·000125  | ·201166 |
| 12     | 1½       | = 1      | ·3333333 | ·0151515 | ·0001894 | ·304797 |
| 36     | 4½       | 3        | = 1      | ·0454545 | ·0005682 | ·914392 |
| 792    | 100      | 66       | 22       | = 1      | ·0125    | 20·1166 |
| 63360  | 8000     | 5280     | 1760     | 80       | = 1      | 1609·33 |



## SQUARE MEASURE.

| Inches  | Feet    | Yards    | Perches  | Roods     | Acres     | Sq. Metres |
|---------|---------|----------|----------|-----------|-----------|------------|
| 1       | 0.08344 | 0.007716 | 0.000255 | 0.0000064 | 0.0000016 | 0.006452   |
| 144     | = 1     | 0.111111 | 0.0367   | 0.000918  | 0.00023   | 0.092901   |
| 1296    | 9       | = 1      | 0.331    | 0.008264  | 0.002066  | 0.836112   |
| 39204   | 272 1/4 | 30 1/2   | = 1      | 0.25      | 0.0625    | 25.292     |
| 1568160 | 10890   | 1210     | 40       | = 1       | 25        | 1011.678   |
| 6272640 | 43560   | 4840     | 160      | 4         | = 1       | 4046.7     |

Acres  $\times$  5 = sq. miles. Sq. yards  $\times$  0.00000529 = sq. miles.

## LAND MEASURE (SQUARE).

| Links  | Perches | Chains | Roods  | Acres  | Sq. Metres |
|--------|---------|--------|--------|--------|------------|
| 1      | 0.016   | 0.001  | 0.0004 | 0.0001 | 0.04046    |
| 625    | = 1     | 0.625  | 0.25   | 0.0625 | 25.292     |
| 10000  | 16      | = 1    | 4      | 1      | 40.467     |
| 25000  | 40      | 2 1/2  | = 1    | 25     | 1011.698   |
| 100000 | 160     | 10     | 4      | = 1    | 4046.782   |

A hide of land = 100 acres.

A yard of land = 30 acres.

A chain wide = 8 acres per mile.

## CUBIC MEASURE.

| Imperial Gallons | Cub. Ins. | Cub. Feet | Cub. Yds. | Cub. Metre |
|------------------|-----------|-----------|-----------|------------|
| 0.03606540822    | = 1       | 0.005785  | 0.0000214 | 0.00016387 |
| 6.232102541168   | 1728      | = 1       | 0.370370  | 0.283161   |
| 168.266768641554 | 46656     | 27        | = 1       | 0.764584   |

A cubic yard of earth = 1 load.

A barrel bulk = 5 cub. ft.

Ton of displacement of a ship = 35 cub. ft. = 0.910624 cub. metre.

## WINE MEASURE.

| Cub. Ins. | Gills | Pints | Quarts | Gallons | Ankers | Runlets | Barrels | Tierces | Hogheads | Punchons | Pipes of<br>Bordeaux | Tuns |
|-----------|-------|-------|--------|---------|--------|---------|---------|---------|----------|----------|----------------------|------|
| 8.66413   | = 1   |       |        |         |        |         |         |         |          |          |                      |      |
| 34.6594   | 4     | = 1   |        |         |        |         |         |         |          |          |                      |      |
| 69.3188   | 8     | 2     | = 1    |         |        |         |         |         |          |          |                      |      |
| 277.274   | 32    | 8     | 4      | = 1     |        |         |         |         |          |          |                      |      |
| 2772.740  | 320   | 80    | 40     | 10      | = 1    |         |         |         |          |          |                      |      |
| 4990.932  | 576   | 144   | 72     | 18      | 1 1/4  | = 1     |         |         |          |          |                      |      |
| 8784.131  | 1008  | 252   | 126    | 31 1/2  | 3 3/10 | 1 1/2   | = 1     |         |          |          |                      |      |
| 11645.508 | 1344  | 336   | 168    | 42      | 4 1/2  | 2 1/2   | 1 1/2   | = 1     |          |          |                      |      |
| 17468.262 | 2016  | 504   | 252    | 63      | 6 3/10 | 3 3/4   | 2       | 1 1/2   | = 1      |          |                      |      |
| 23291.016 | 2688  | 672   | 336    | 84      | 8 1/2  | 4 3/4   | 2 3/4   | 2       | 1 1/2    | = 1      |                      |      |
| 34938.324 | 4032  | 1008  | 504    | 126     | 12 1/2 | 7       | 4       | 3       | 2        | 1 1/2    | = 1                  |      |
| 69878.048 | 8064  | 2016  | 1008   | 252     | 25 1/2 | 14      | 8       | 6       | 4        | 3        | 2                    | = 1  |

ALE AND BEER MEASURE.

| Cub. Ins.            | Pints | Quarts | Gallons | Firkins | Kilderkins | Barrels         | Hogheads        | Punchoons       | Butts | Tuns | Last |
|----------------------|-------|--------|---------|---------|------------|-----------------|-----------------|-----------------|-------|------|------|
| 34.659 $\frac{1}{2}$ | = 1   |        |         |         |            |                 |                 |                 |       |      |      |
| 69.318 $\frac{1}{2}$ | 2     | = 1    |         |         |            |                 |                 |                 |       |      |      |
| 277.274              | 8     | 4      | = 1     |         |            |                 |                 |                 |       |      |      |
| 2495.446             | 72    | 36     | 9       | = 1     |            |                 |                 |                 |       |      |      |
| 4990.882             | 144   | 72     | 18      | 2       | = 1        |                 |                 |                 |       |      |      |
| 9981.864             | 288   | 144    | 36      | 4       | 2          | = 1             |                 |                 |       |      |      |
| 14972.796            | 432   | 216    | 54      | 6       | 3          | 1 $\frac{1}{2}$ | = 1             |                 |       |      |      |
| 19963.728            | 576   | 288    | 72      | 8       | 4          | 2               | 1 $\frac{1}{2}$ | = 1             |       |      |      |
| 29945.592            | 864   | 432    | 108     | 12      | 6          | 3               | 2               | 1 $\frac{1}{2}$ | = 1   |      |      |
| 59891.184            | 1728  | 864    | 216     | 24      | 12         | 6               | 4               | 3               | 2     | = 1  |      |
| 119782.368           | 3456  | 1728   | 432     | 48      | 24         | 12              | 8               | 6               | 4     | 2    | = 1  |

CORN AND DRY MEASURE.

| Cub. Ins.<br>Heaped<br>Measure | Pints | Quarts | Pottles | Gallons | Pecks | Bushels | Strikes | Sacks | Quartals | Loads | Last |
|--------------------------------|-------|--------|---------|---------|-------|---------|---------|-------|----------|-------|------|
| 34.659 $\frac{1}{2}$           | = 1   |        |         |         |       |         |         |       |          |       |      |
| 69.318 $\frac{1}{2}$           | 2     | = 1    |         |         |       |         |         |       |          |       |      |
| 138.637                        | 4     | 2      | = 1     |         |       |         |         |       |          |       |      |
| 277.274                        | 8     | 4      | 2       | = 1     |       |         |         |       |          |       |      |
| 554.548                        | 16    | 8      | 4       | 2       | = 1   |         |         |       |          |       |      |
| 9218.192                       | 64    | 32     | 16      | 8       | 4     | = 1     |         |       |          |       |      |
| 4436.384                       | 128   | 64     | 32      | 16      | 8     | 2       | = 1     |       |          |       |      |
| 8872.768                       | 256   | 128    | 64      | 32      | 16    | 4       | 2       | = 1   |          |       |      |
| 17745.536                      | 512   | 256    | 128     | 64      | 32    | 8       | 4       | 2     | = 1      |       |      |
| 88727.680                      | 2560  | 1280   | 640     | 320     | 160   | 40      | 20      | 10    | 6        | = 1   |      |
| 177455.360                     | 5120  | 2560   | 1280    | 640     | 320   | 80      | 40      | 20    | 10       | 12    | = 1  |

COAL MEASURE.

| Cub. Ins.<br>Heaped<br>Measure | Lbs.<br>Avoir.    | Pecks | Bushels          | Sacks            | Vats or<br>Strikes | Chaldrs.         | Newer<br>Chaldrs. | Keels            | Score             | Ship<br>Load. |
|--------------------------------|-------------------|-------|------------------|------------------|--------------------|------------------|-------------------|------------------|-------------------|---------------|
| 703.872                        | 183 $\frac{1}{2}$ | = 1   |                  |                  |                    |                  |                   |                  |                   |               |
| 2815.487                       | 74 $\frac{1}{2}$  | 4     | = 1              |                  |                    |                  |                   |                  |                   |               |
| 8446.461                       | 224               | 12    | 3                | = 1              |                    |                  |                   |                  |                   |               |
| 25339.383                      | 672               | 36    | 9                | 3                | = 1                |                  |                   |                  |                   |               |
| 101367.532                     | 2688              | 144   | 36               | 12               | 4                  | = 1              |                   |                  |                   |               |
| 196380.218 $\frac{1}{2}$       | 5208              | 279   | 69 $\frac{1}{2}$ | 23 $\frac{1}{2}$ | 7 $\frac{1}{2}$    | 1 $\frac{1}{2}$  | = 1               |                  |                   |               |
| 1571041.746                    | 41664             | 2232  | 558              | 186              | 62                 | 16 $\frac{1}{2}$ | 8                 | = 1              |                   |               |
| 2128508.172                    | 56448             | 3024  | 756              | 252              | 84                 | 21               | 10 $\frac{3}{4}$  | 14 $\frac{1}{2}$ | = 1               |               |
| 31420834.92                    | 833280            | 44640 | 11160            | 3720             | 1240               | 310              | 160               | 20               | 144 $\frac{1}{2}$ | = 1           |

WOOL WEIGHT.

| Pounds | Cloves | Stones | Tods | Ways      | Packs     | Sacks | Last |
|--------|--------|--------|------|-----------|-----------|-------|------|
| 7      | = 1    |        |      |           |           |       |      |
| 14     | 2      | = 1    |      |           |           |       |      |
| 28     | 4      | 2      | = 1  |           |           |       |      |
| 182    | 26     | 13     | 6½   | = 1       |           |       |      |
| 240    | 34½    | 17½    | 8½   | 129<br>91 | = 1       |       |      |
| 364    | 52     | 26     | 13   | 2         | 113<br>80 | = 1   |      |
| 4368   | 624    | 312    | 156  | 24        | 18½       | 12    | = 1  |

MEASURE OF TIME.

| Seconds  | Minutes | Hours | Days | Weeks | Months     | Calend.<br>Year | Julian<br>Year | Leap<br>Year |
|----------|---------|-------|------|-------|------------|-----------------|----------------|--------------|
| 60       | = 1     |       |      |       |            |                 |                |              |
| 3600     | 60      | = 1   |      |       |            |                 |                |              |
| 86400    | 1440    | 24    | = 1  |       |            |                 |                |              |
| 604800   | 10080   | 168   | 7    | = 1   |            |                 |                |              |
| 2419200  | 40320   | 672   | 28   | 4     | = 1        |                 |                |              |
| 31536000 | 525600  | 8760  | 365  | 52½   | 13½<br>28  | = 1             |                |              |
| 31557600 | 525960  | 8766  | 365½ | 52⅝   | 13⅝<br>112 | 1½<br>1460      | = 1            |              |
| 31622400 | 527040  | 8784  | 366  | 52¾   | 13¾<br>14  | 1⅛<br>565       | 1¼<br>487      | = 1          |

ANGULAR MEASURE.

| The Geographical Division of any Line round the<br>Circumference of the Earth                          | Diurnal Motion<br>of the Earth<br>reduced to Time |
|--|---|
| 60 seconds = 1 minute . . . . .  | = 4 seconds                                       |
| 60 minutes = 1 degree . . . . .  | = 4 minutes                                       |
| 15 degrees = ¼ sign of the zodiac . . . . .  | = 1 hour  |
| 30 degrees = ½ sign of the zodiac . . . . .  | = 2 hours   |
| 90 degrees = 1 quadrant . . . . .  | = 6 hours   |
| 1 revolution or 4 quadrants or 360 degrees = the<br>earth's circumf., or 12 signs = 1 great circle . } | = 24 hours  |

COKE.

4 bushels = 1 sack. 12 sacks = 1 chaldron. 21 chaldrons = 1 score.

MISCELLANEOUS WEIGHTS AND MEASURES.

|                                       |                   |
|---------------------------------------|-------------------|
| Aume of hock . . . . .                | 81 gals.          |
| Bag of cocoa . . . . .                | 112 lbs.          |
| „ coffee . . . . .                    | 140 to 168 „      |
| „ hops . . . . .                      | 280 „             |
| „ pepper (black), company's . . . . . | 316 „             |
| „ „ free-trade bags . . . . .         | 28, 56, and 112 „ |
| „ „ (white) . . . . .                 | 168 „             |
| „ rice . . . . .                      | 168 „             |
| „ sago . . . . .                      | 112 „             |

MISCELLANEOUS WEIGHTS AND MEASURES (continued).

|   |                 |
|---|-----------------|
| Bag of saltpetre (East India) . . . . .         | 168 lbs.        |
| „ sugar or malt (Mauritius). . . . .            | 112 to 168 „    |
| „ „ (East India) . . . . .                      | 112 to 196 „    |
| „ biscuits (Admiralty). . . . .                 | 102 „           |
| Bale of coffee (Mocha) . . . . .                | 224 to 280 „    |
| „ cotton wool (Virginia, Carolina, & W. Indies) | 300 to 310 „    |
| „ „ „ (New Orleans and Alabama) .               | 400 to 500 „    |
| „ „ „ (East India) . . . . .                    | 320 to 360 „    |
| „ „ „ (Brazil) . . . . .                        | 160 to 200 „    |
| „ „ „ (Egyptian) . . . . .                      | 180 to 280 „    |
| „ rags (Mediterranean) . . . . .                | 448 to 476 „    |
| Bar of bullion . . . . .                        | 15 to 30 „      |
| Barrel of raisins . . . . .                     | 112 „           |
| „ soap . . . . .                                | 256 „           |
| „ anchovies . . . . .                           | 30 „            |
| „ coffee . . . . .                              | 112 to 168 „    |
| „ tar . . . . .                                 | 26.5 gals.      |
| „ turpentine . . . . .                          | 224 to 280 lbs. |
| „ flour . . . . .                               | 220 „           |
| „ pork . . . . .                                | 224 „           |
| Boll of flour . . . . .                         | 140 „           |
| Box of camphor . . . . .                        | 112 „           |
| „ raisins (Valencia) . . . . .                  | 80 to 40 „      |
| Bushel of wheat . . . . .                       | 60 „            |
| „ flour . . . . .                               | 56 „            |
| „ rye . . . . .                                 | 58 „            |
| „ barley . . . . .                              | 47 „            |
| „ oats . . . . .                                | 40 „            |
| „ oatmeal . . . . .                             | 51 „            |
| „ peas . . . . .                                | 64 „            |
| „ beans . . . . .                               | 63 „            |
| „ rape seed . . . . .                           | 50 „            |
| „ malt . . . . .                                | 38 „            |
| „ salt . . . . .                                | 56 „            |
| „ clover (red) . . . . .                        | 64 „            |
| „ „ (white) . . . . .                           | 62 „            |
| „ linseed . . . . .                             | 52 „            |
| „ chicory (raw) . . . . .                       | 50 „            |
| „ „ (kiln-dried) . . . . .                      | 28 „            |
| „ „ (powdered) . . . . .                        | 38 „            |
| „ coffee (raw) . . . . .                        | 51.25 „         |
| „ „ (roasted) . . . . .                         | 32.25 „         |
| „ „ (ground) . . . . .                          | 36 „            |
| „ buck wheat . . . . .                          | 50 to 56 „      |
| „ canary seed . . . . .                         | 53 to 61 „      |
| „ hemp „ . . . . .                              | 42 to 44 „      |
| „ lentil „ . . . . .                            | 60 to 62 „      |
| „ linseed (Bombay). . . . .                     | 50 to 52 „      |

## MISCELLANEOUS WEIGHTS AND MEASURES (continued).

|   |                     |
|---|---------------------|
| Bushel of onion seed                          | 36 to 38 lbs.       |
| „ millet „                                    | 56 to 64 „          |
| „ poppy „                                     | 48 „                |
| „ rape „                                      | 48 to 53 „          |
| „ tare „                                      | 62 to 66 „          |
| „ turnip „                                    | 50 to 56 „          |
| „ cabbage „                                   | 50 to 56 „          |
| Butt of currants                              | 1,680 to 2,240 „    |
| „ cadiz                                       | 108 gals.           |
| „ sherry                                      | 108 „               |
| Cask of cocoa                                 | 140 lbs.            |
| „ mustard                                     | 9 to 18 „           |
| „ nutmegs                                     | 200 „               |
| „ rice (American)                             | 672 „               |
| „ tallow                                      | 1,008 „             |
| Catty of tea                                  | 1.33 „              |
| Chaldron of coals                             | 2.63 tons           |
| Chest of tea (Congou) about                   | 82.5 lbs.           |
| „ „ (Souchong) „                              | 81.0 „              |
| „ „ (Pekoe) „                                 | 65.5 „              |
| „ „ (Hyson and Hyson skin) about              | 65 „                |
| „ „ (Gunpowder) about                         | 109 „               |
| „ „ (Imperial) about                          | 95.7 „              |
| „ „ (Young Hyson)                             | 94 „                |
| Cran of herrings                              | 37.5 gals.          |
| Firkin of butter                              | 56 lbs.             |
| „ soap  | 64 „                |
| Hogshead of brandy                            | 45 to 60 gals.      |
| „ „ rum                                       | 45 to 50 „          |
| „ „ tobacco                                   | 1,344 to 2,016 lbs. |
| „ „ sugar                                     | 1,456 to 1,792 „    |
| „ „ whisky                                    | 55 to 60 gals.      |
| „ „ burgundy                                  | 44 „                |
| „ „ claret                                    | 46 „                |
| „ „ lisbon                                    | 58 „                |
| „ „ port                                      | 57 „                |
| „ „ sherry                                    | 54 „                |
| Jar of olive oil                              | 25 „                |
| Last of salt                                  | 18 barrels          |
| „ potash, cod fish, herrings, meal, soap, tar | 12 „                |
| „ flax or feathers                            | 1,904 lbs.          |
| „ ale or beer                                 | 12 barrels          |
| „ gunpowder                                   | 24 „                |
| Load of hay or straw                          | 36 trusses          |
| „ bricks                                      | 500 number          |
| „ tiles                                       | 1,000 „             |
| Pig of ballast                                | 56 lbs.             |
| Pipe of Cape wine                             | 92 gals.            |
| „ „ Lisbon or Bucellas                        | 117 „               |

MISCELLANEOUS WEIGHTS AND MEASURES (concluded).

|                                     |                  |
|-------------------------------------|------------------|
| Pipe of madeira                     | 110 gals.        |
| „ malaga                            | 105 „            |
| „ marsala                           | 108 „            |
| „ port                              | 113 to 115 „     |
| „ sherry or tent                    | 92 to 108 „      |
| „ teneriffe or vidonia              | 100 „            |
| Pocket of hops                      | 168 to 224 lbs.  |
| Puncheon of brandy                  | 110 to 120 gals. |
| „ „ rum                             | 90 to 100 „      |
| „ „ whisky (Scottish)               | 112 to 130 „     |
| „ „ prunes                          | 1,120 lbs.       |
| „ „ molasses                        | 1,120 to 1,344 „ |
| Quintal of fish                     | 112 „            |
| Roll of parchment                   | 60 skins         |
| Sack of coals                       | 224 lbs.         |
| „ flour of 2 bolls                  | 280 „            |
| Tierce of beef (Irish) of 38 pieces | 304 „            |
| „ coffee                            | 560 to 784 „     |
| „ pork (Irish) of 80 pieces         | 320 „            |
| Truss of straw                      | 36 „             |
| „ old hay                           | 56 „             |
| „ new hay                           | 60 „             |
| Tub of butter                       | 84 „             |
| Tun of oil (wine gals.)             | 252 gals.        |

MISCELLANEOUS NUMBERS.

|                                   |                                 |
|-----------------------------------|---------------------------------|
| 12 units                          | make 1 dozen                    |
| 13 units                          | „ 1 long dozen                  |
| 12 dozen                          | „ 1 gross                       |
| 12 gross, or 144 dozen            | „ 1 great gross                 |
| 20 units                          | „ 1 score                       |
| 21 units                          | „ 1 long score                  |
| 5 score, or 100                   | „ 1 short hundred               |
| 6 score, or 120                   | „ 1 long hundred                |
| 24 sheets                         | „ 1 quire of paper or parchment |
| 20 sheets                         | „ 1 quire of outside            |
| 25 sheets                         | „ 1 printer's quire             |
| 20 quires, or 472 sheets          | „ 1 ream of ditto or parchment  |
| 21½ quires, or 516 sheets         | „ 1 perfect or printer's ream   |
| 2 reams                           | „ 1 bundle of ditto             |
| 10 reams, or 200 quires           | „ 1 bale                        |
| 5 doz., or 60 skins, of parchment | „ 1 roll                        |
| 4 pages, or 2 leaves              | „ 1 sheet of folio              |
| 8 pages, or 4 leaves              | „ 1 sheet of quarto or 4to.     |
| 16 pages, or 8 leaves             | „ 1 sheet of octavo or 8vo.     |
| 24 pages, or 12 leaves            | „ 1 sheet of duodecimo or 12mo. |
| 36 pages, or 18 leaves            | „ 1 sheet of eighteens or 18mo. |
| 72 words in common law            | „ 1 sheet                       |
| 80 words in exchequer             | „ 1 sheet                       |
| 90 words in chancery              | „ 1 sheet                       |

## 122 METRICAL SYSTEM OF WEIGHTS AND MEASURES.

### SIZES AND CONTENTS OF CASKS.

| Sundry Casks   | Length<br>(ins.) | Diam.<br>(ins.) | Contents<br>(gals.) | Admiralty Casks | Length<br>(ins.) | Diam.<br>(ins.) | Contents<br>(gals.) |
|----------------|------------------|-----------------|---------------------|-----------------|------------------|-----------------|---------------------|
| Marsala pipe . | 65               | 32              | 108                 | Leager .        | 59               | 38              | 164                 |
| " hhd. .       | 41               | 25              | 45.5                | Butt .          | 53               | 33              | 110                 |
| Brandy pipe .  | 52               | 34              | 114                 | Puncheon .      | 41½              | 30              | 72                  |
| " hhd. .       | 40               | 28              | 57.5                | Hogshead .      | 37               | 28              | 54                  |
| Port pipe .    | 58               | 34              | 118                 | Barrel .        | 31½              | 24.5            | 36                  |
| " hhd. .       | 37               | 30              | 56.5                | Half-hogshead   | 28               | 22.5            | 27                  |
| Sherry butt .  | 50               | 35              | 108                 | Kilderkin .     | 25               | 19.75           | 18                  |
| " hhd. .       | 38               | 28              | 54.5                | Firkin .        | 22               | 17              | 12                  |
| Rum puncheon   | 42               | 36              | 91                  |                 |                  |                 |                     |

### SIZE OF DRAWING PAPERS.

|                 | inches  |                  | inches   |
|-----------------|---------|------------------|----------|
| Antiquarian .   | 53 × 31 | Royal .          | 24 × 19  |
| Double elephant | 40 × 27 | Medium .         | 22 × 17  |
| Atlas .         | 34 × 26 | Demy .           | 20 × 15  |
| Colombier .     | 34 × 23 | Foolscap .       | 17 × 13½ |
| Imperial .      | 30 × 22 | Tracing papers . | 30 × 20  |
| Elephant .      | 28 × 23 | Ditto .          | 30 × 40  |
| Super royal .   | 27 × 19 | Ditto .          | 60 × 40  |

Continuous tracing paper, 28, 31, 40, 44, and 56 in. wide by 21 yards long.  
 Continuous tracing linen, 18, 28, 36, 38, and 41 in. wide by 24 yards long.  
 Continuous drawing cartridge, 54, 57, 58, and 60 in. wide by 50 yards long.

### METRICAL SYSTEM.

#### LONG MEASURE (1).

|                      | Metres | inches   | Feet      | Yards     | Miles    |
|----------------------|--------|----------|-----------|-----------|----------|
| Millimetre .         | = .001 | .03937   | .00328    | .00109    | —        |
| Centimetre .         | .01    | .39370   | .03281    | .01094    | .000006  |
| Decimetre .          | .1     | 3.93704  | .32809    | .10936    | .000062  |
| Metre <sup>1</sup> . | 1      | 39.37043 | 3.28087   | 1.09362   | .000621  |
| Decametre .          | 10     | 393.7043 | 32.80869  | 10.93623  | .006214  |
| Hectometre .         | 100    | 3937.043 | 328.08693 | 109.36231 | .062188  |
| Kilometre .          | 1000   | 39370.43 | 3280.8693 | 1093.6231 | .621877  |
| Myriametre .         | 10000  | 393704.3 | 32808.693 | 10936.231 | 6.218768 |

#### SQUARE MEASURE.

|                    | Sq. Metres | Sq. Inches | Sq. Feet  | Sq. Yards | Acres     |
|--------------------|------------|------------|-----------|-----------|-----------|
| Milliare .         | = .1       | 155        | 1.076     | .119601   | .0000247  |
| Centiare .         | 1          | 1550       | 10.764    | 1.19601   | .0002471  |
| Deciare .          | 10         | 15500      | 107.641   | 11.9601   | .0024711  |
| Are <sup>2</sup> . | 100        | 155003     | 1076.410  | 119.601   | .0247110  |
| Decare .           | 1000       | 1550031    | 10764.104 | 1196.01   | .2471096  |
| Hectare .          | 10000      | 15500309   | 107641.04 | 11960.12  | 2.4710981 |

<sup>1</sup> See Long Measure, next page.

<sup>2</sup> The are—the square decimetre.

## LONG MEASURE (2).

|             | Inches and Decimals of an Inch | Miles | Furlongs | Poles | Yards         | Feet | Inches and Fractions of an Inch |
|-------------|--------------------------------|-------|----------|-------|---------------|------|---------------------------------|
| Millimetre. | = .0394                        |       |          |       |               |      | $\frac{1}{25.4}$ +              |
| Centimetre  | .3937                          |       |          |       |               |      | $\frac{1}{2.54}$ +              |
| Decimetre.  | 3.9370                         |       |          |       |               |      | $\frac{1}{.254}$ +              |
| Metre       | 39.3704                        |       |          |       | 1             | 0    | $\frac{1}{.03937}$ +            |
| Decametre.  | 393.7043                       |       |          | 1     | $\frac{1}{4}$ | 2    | $\frac{1}{.003937}$ +           |
| Hectometre  | 3937.0432                      |       |          | 19    | $\frac{1}{4}$ | 1    | $\frac{1}{.0003937}$ +          |
| Kilometre.  | 39370.4320                     | 4     |          | 38    | $\frac{1}{4}$ | 1    | $\frac{1}{.00003937}$ +         |
| Myriametre  | 393704.3196                    | 6     | 1        | 28    | $\frac{1}{2}$ | 0    | $\frac{1}{.000003937}$ +        |

## SOLID MEASURE.

|                    | Cubic Metres | Cubic Inches | Cubic Feet | Cubic Yards |
|--------------------|--------------|--------------|------------|-------------|
| Millistere         | = .001       | 61.025       | .03532     | .000136     |
| Centistere         | .01          | 610.254      | .35316     | .01308      |
| Decistere          | .1           | 6102.539     | 3.53156    | .13047      |
| Stere <sup>1</sup> | 1            | 61025.387    | 35.31562   | 1.30465     |
| Decastere          | 10           | 610253.866   | 353.15617  | 13.04653    |
| Hectostere         | 100          | 6102538.659  | 3531.56172 | 130.46525   |

## WEIGHTS.

|                                | Grammes | Az. Oz. | Az. Lbs. | Cwt.     | Tons    | Grains Tr. |
|--------------------------------|---------|---------|----------|----------|---------|------------|
| Milligramme                    | = .001  | .00004  | .000022  | —        | —       | .015432    |
| Centigramme                    | .01     | .00035  | .000221  | —        | —       | .154323    |
| Decigramme                     | .1      | .00353  | .002205  | .00002   | —       | 1.543235   |
| Gramme <sup>2</sup>            | 1       | .03527  | .022046  | .000197  | .000001 | 15.43235   |
| Decagramme                     | 10      | .35274  | .220462  | .001968  | .000010 | 154.3235   |
| Hectogramme                    | 100     | 3.5274  | 2.204621 | .019684  | .000098 | 1543.235   |
| Kilogramme                     | 1000    | 35.2739 | 2.204621 | .0196841 | .000984 | 15432.35   |
| Myriagramme                    | 10000   | 352.739 | 22.04621 | .1968412 | .0098   | 154323.5   |
| Quintal                        | 100000  | 3527.39 | 220.4621 | 1.968412 | .098421 | 1543235    |
| Millier, or Tonne <sup>3</sup> | 1000000 | 35273.9 | 2204.621 | 19.68412 | .984206 | 15432354.9 |

## DRY AND FLUID MEASURE.

|                    | Litres | Cubic Inches | Cubic Feet | Gallons   | Bushels   |
|--------------------|--------|--------------|------------|-----------|-----------|
| Millilitre         | = .001 | .06102539    | —          | .00022    | .000009   |
| Centilitre         | .01    | .61025387    | .0004      | .0022     | .00028    |
| Decilitre          | .1     | 6.1025387    | .0035      | .0220     | .00275    |
| Litre <sup>4</sup> | 1      | 61.025387    | .0353      | .2201     | .02751    |
| Decalitre          | 10     | 610.25387    | .3532      | 2.2009    | .27511    |
| Hectolitre         | 100    | 6102.5387    | 3.5316     | 22.0091   | 2.75113   |
| Kilolitre          | 1000   | 61025.387    | 35.3156    | 220.0905  | 27.51132  |
| Myrialitre         | 10000  | 610253.87    | 353.1562   | 2200.9055 | 275.11318 |

<sup>1</sup> The stere is a cubic metre, and is used generally for measuring solids.<sup>2</sup> The gramme is the weight in vacuo of a cubic centimetre of distilled water at the temperature of 4° of the centigrade thermometer.<sup>3</sup> Or tonneau in ship-building.<sup>4</sup> The litre is a cubic decimetre.



TABLES GIVING THE ENGLISH EQUIVALENTS OF 1 MILLI-METRE TO 1,000, AND OF 1 METRE TO 100, IN INCHES AND DECIMAL PARTS OF AN INCH.

| Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch |
|------------------|--------------------------------------|------------------|--------------------------------------|------------------|--------------------------------------|
|                  |                                      | 39               | 1.535447                             | 78               | 3.070894                             |
| 1                | 0.039370                             | 40               | 1.574817                             | 79               | 3.110264                             |
| 2                | 0.078741                             | 41               | 1.614188                             | 80               | 3.149635                             |
| 3                | 0.118111                             | 42               | 1.653558                             | 81               | 3.189005                             |
| 4                | 0.157482                             | 43               | 1.692929                             | 82               | 3.228375                             |
| 5                | 0.196852                             | 44               | 1.732299                             | 83               | 3.267746                             |
| 6                | 0.236223                             | 45               | 1.771669                             | 84               | 3.307116                             |
| 7                | 0.275593                             | 46               | 1.811040                             | 85               | 3.346487                             |
| 8                | 0.314963                             | 47               | 1.850410                             | 86               | 3.385857                             |
| 9                | 0.354334                             | 48               | 1.889781                             | 87               | 3.425228                             |
| 10               | 0.393704                             | 49               | 1.929151                             | 88               | 3.464598                             |
| 11               | 0.433075                             | 50               | 1.968522                             | 89               | 3.503968                             |
| 12               | 0.472445                             | 51               | 2.007892                             | 90               | 3.543339                             |
| 13               | 0.511816                             | 52               | 2.047262                             | 91               | 3.582709                             |
| 14               | 0.551186                             | 53               | 2.086633                             | 92               | 3.622080                             |
| 15               | 0.590556                             | 54               | 2.126003                             | 93               | 3.661450                             |
| 16               | 0.629927                             | 55               | 2.165374                             | 94               | 3.700821                             |
| 17               | 0.669297                             | 56               | 2.204744                             | 95               | 3.740191                             |
| 18               | 0.708668                             | 57               | 2.244115                             | 96               | 3.779561                             |
| 19               | 0.748038                             | 58               | 2.283485                             | 97               | 3.818932                             |
| 20               | 0.787409                             | 59               | 2.322855                             | 98               | 3.858302                             |
| 21               | 0.826779                             | 60               | 2.362226                             | 99               | 3.897673                             |
| 22               | 0.866149                             | 61               | 2.401596                             | 100              | 3.937043                             |
| 23               | 0.905520                             | 62               | 2.440967                             | 101              | 3.976414                             |
| 24               | 0.944890                             | 63               | 2.480337                             | 102              | 4.015784                             |
| 25               | 0.984261                             | 64               | 2.519708                             | 103              | 4.055155                             |
| 26               | 1.023631                             | 65               | 2.559078                             | 104              | 4.094525                             |
| 27               | 1.063002                             | 66               | 2.598448                             | 105              | 4.133895                             |
| 28               | 1.102372                             | 67               | 2.637819                             | 106              | 4.173266                             |
| 29               | 1.141742                             | 68               | 2.677189                             | 107              | 4.212636                             |
| 30               | 1.181113                             | 69               | 2.716560                             | 108              | 4.252007                             |
| 31               | 1.220483                             | 70               | 2.755930                             | 109              | 4.291377                             |
| 32               | 1.259854                             | 71               | 2.795301                             | 110              | 4.330748                             |
| 33               | 1.299224                             | 72               | 2.834671                             | 111              | 4.370118                             |
| 34               | 1.338595                             | 73               | 2.874041                             | 112              | 4.409488                             |
| 35               | 1.377965                             | 74               | 2.913412                             | 113              | 4.448859                             |
| 36               | 1.417335                             | 75               | 2.952782                             | 114              | 4.488229                             |
| 37               | 1.456706                             | 76               | 2.992153                             | 115              | 4.527600                             |
| 38               | 1.496076                             | 77               | 3.031523                             | 116              | 4.566970                             |

| Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch |
|------------------|--------------------------------------|------------------|--------------------------------------|------------------|--------------------------------------|
| 117              | 4.606341                             | 165              | 6.496121                             | 213              | 8.385902                             |
| 118              | 4.645711                             | 166              | 6.535492                             | 214              | 8.425272                             |
| 119              | 4.685081                             | 167              | 6.574862                             | 215              | 8.464648                             |
| 120              | 4.724452                             | 168              | 6.614233                             | 216              | 8.504018                             |
| 121              | 4.763822                             | 169              | 6.653603                             | 217              | 8.543384                             |
| 122              | 4.803193                             | 170              | 6.692973                             | 218              | 8.582754                             |
| 123              | 4.842563                             | 171              | 6.732344                             | 219              | 8.622125                             |
| 124              | 4.881934                             | 172              | 6.771714                             | 220              | 8.661495                             |
| 125              | 4.921304                             | 173              | 6.811085                             | 221              | 8.700866                             |
| 126              | 4.960674                             | 174              | 6.850455                             | 222              | 8.740236                             |
| 127              | 5.000045                             | 175              | 6.889826                             | 223              | 8.779606                             |
| 128              | 5.039415                             | 176              | 6.929196                             | 224              | 8.818977                             |
| 129              | 5.078786                             | 177              | 6.968567                             | 225              | 8.858347                             |
| 130              | 5.118156                             | 178              | 7.007937                             | 226              | 8.897718                             |
| 131              | 5.157527                             | 179              | 7.047307                             | 227              | 8.937088                             |
| 132              | 5.196897                             | 180              | 7.086678                             | 228              | 8.976459                             |
| 133              | 5.236267                             | 181              | 7.126048                             | 229              | 9.015829                             |
| 134              | 5.275638                             | 182              | 7.165419                             | 230              | 9.055199                             |
| 135              | 5.315008                             | 183              | 7.204789                             | 231              | 9.094570                             |
| 136              | 5.354379                             | 184              | 7.244160                             | 232              | 9.133940                             |
| 137              | 5.393749                             | 185              | 7.283530                             | 233              | 9.173311                             |
| 138              | 5.433120                             | 186              | 7.322900                             | 234              | 9.212681                             |
| 139              | 5.472490                             | 187              | 7.362271                             | 235              | 9.252052                             |
| 140              | 5.511861                             | 188              | 7.401641                             | 236              | 9.291422                             |
| 141              | 5.551231                             | 189              | 7.441012                             | 237              | 9.330792                             |
| 142              | 5.590601                             | 190              | 7.480382                             | 238              | 9.370163                             |
| 143              | 5.629972                             | 191              | 7.519753                             | 239              | 9.409533                             |
| 144              | 5.669342                             | 192              | 7.559123                             | 240              | 9.448904                             |
| 145              | 5.708713                             | 193              | 7.598493                             | 241              | 9.488274                             |
| 146              | 5.748083                             | 194              | 7.637864                             | 242              | 9.527645                             |
| 147              | 5.787454                             | 195              | 7.677234                             | 243              | 9.567015                             |
| 148              | 5.826824                             | 196              | 7.716605                             | 244              | 9.606385                             |
| 149              | 5.866194                             | 197              | 7.755975                             | 245              | 9.645756                             |
| 150              | 5.905565                             | 198              | 7.795346                             | 246              | 9.685126                             |
| 151              | 5.944935                             | 199              | 7.834716                             | 247              | 9.724497                             |
| 152              | 5.984306                             | 200              | 7.874086                             | 248              | 9.763867                             |
| 153              | 6.023676                             | 201              | 7.913457                             | 249              | 9.803238                             |
| 154              | 6.063047                             | 202              | 7.952827                             | 250              | 9.842608                             |
| 155              | 6.102417                             | 203              | 7.992198                             | 251              | 9.881978                             |
| 156              | 6.141787                             | 204              | 8.031568                             | 252              | 9.921349                             |
| 157              | 6.181158                             | 205              | 8.070939                             | 253              | 9.960719                             |
| 158              | 6.220528                             | 206              | 8.110309                             | 254              | 10.000090                            |
| 159              | 6.259899                             | 207              | 8.149679                             | 255              | 10.039460                            |
| 160              | 6.299269                             | 208              | 8.189050                             | 256              | 10.078831                            |
| 161              | 6.338640                             | 209              | 8.228420                             | 257              | 10.118201                            |
| 162              | 6.378010                             | 210              | 8.267791                             | 258              | 10.157571                            |
| 163              | 6.417380                             | 211              | 8.307161                             | 259              | 10.196942                            |
| 164              | 6.456751                             | 212              | 8.346532                             | 260              | 10.236312                            |

| Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch |
|------------------|--------------------------------------|------------------|--------------------------------------|------------------|--------------------------------------|
| 261              | 10.275683                            | 309              | 12.165464                            | 357              | 14.055244                            |
| 262              | 10.315053                            | 310              | 12.204834                            | 358              | 14.094615                            |
| 263              | 10.354424                            | 311              | 12.244204                            | 359              | 14.133985                            |
| 264              | 10.393794                            | 312              | 12.283575                            | 360              | 14.173356                            |
| 265              | 10.433165                            | 313              | 12.322945                            | 361              | 14.212726                            |
| 266              | 10.472535                            | 314              | 12.362316                            | 362              | 14.252096                            |
| 267              | 10.511905                            | 315              | 12.401686                            | 363              | 14.291467                            |
| 268              | 10.551276                            | 316              | 12.441057                            | 364              | 14.330837                            |
| 269              | 10.590646                            | 317              | 12.480427                            | 365              | 14.370208                            |
| 270              | 10.630017                            | 318              | 12.519797                            | 366              | 14.409578                            |
| 271              | 10.669387                            | 319              | 12.559168                            | 367              | 14.448949                            |
| 272              | 10.708758                            | 320              | 12.598538                            | 368              | 14.488319                            |
| 273              | 10.748128                            | 321              | 12.637909                            | 369              | 14.527689                            |
| 274              | 10.787498                            | 322              | 12.677279                            | 370              | 14.567060                            |
| 275              | 10.826869                            | 323              | 12.716650                            | 371              | 14.606430                            |
| 276              | 10.866239                            | 324              | 12.756020                            | 372              | 14.645801                            |
| 277              | 10.905610                            | 325              | 12.795390                            | 373              | 14.685171                            |
| 278              | 10.944980                            | 326              | 12.834761                            | 374              | 14.724542                            |
| 279              | 10.984351                            | 327              | 12.874131                            | 375              | 14.763912                            |
| 280              | 11.023721                            | 328              | 12.913502                            | 376              | 14.803282                            |
| 281              | 11.063091                            | 329              | 12.952872                            | 377              | 14.842653                            |
| 282              | 11.102462                            | 330              | 12.992243                            | 378              | 14.882023                            |
| 283              | 11.141832                            | 331              | 13.031613                            | 379              | 14.921394                            |
| 284              | 11.181203                            | 332              | 13.070983                            | 380              | 14.960764                            |
| 285              | 11.220573                            | 333              | 13.110354                            | 381              | 15.000135                            |
| 286              | 11.259944                            | 334              | 13.149724                            | 382              | 15.039505                            |
| 287              | 11.299314                            | 335              | 13.189095                            | 383              | 15.078875                            |
| 288              | 11.338684                            | 336              | 13.228465                            | 384              | 15.118246                            |
| 289              | 11.378055                            | 337              | 13.267836                            | 385              | 15.157616                            |
| 290              | 11.417425                            | 338              | 13.307206                            | 386              | 15.196987                            |
| 291              | 11.456796                            | 339              | 13.346576                            | 387              | 15.236357                            |
| 292              | 11.496166                            | 340              | 13.385947                            | 388              | 15.275728                            |
| 293              | 11.535537                            | 341              | 13.425317                            | 389              | 15.315098                            |
| 294              | 11.574907                            | 342              | 13.464688                            | 390              | 15.354469                            |
| 295              | 11.614277                            | 343              | 13.504058                            | 391              | 15.393839                            |
| 296              | 11.653648                            | 344              | 13.543429                            | 392              | 15.433209                            |
| 297              | 11.693018                            | 345              | 13.582799                            | 393              | 15.472580                            |
| 298              | 11.732389                            | 346              | 13.622170                            | 394              | 15.511950                            |
| 299              | 11.771759                            | 347              | 13.661540                            | 395              | 15.551321                            |
| 300              | 11.811130                            | 348              | 13.700910                            | 396              | 15.590691                            |
| 301              | 11.850500                            | 349              | 13.740281                            | 397              | 15.630062                            |
| 302              | 11.889871                            | 350              | 13.779651                            | 398              | 15.669432                            |
| 303              | 11.929241                            | 351              | 13.819022                            | 399              | 15.708802                            |
| 304              | 11.968611                            | 352              | 13.858392                            | 400              | 15.748173                            |
| 305              | 12.007982                            | 353              | 13.897763                            | 401              | 15.787543                            |
| 306              | 12.047352                            | 354              | 13.937133                            | 402              | 15.826914                            |
| 307              | 12.086723                            | 355              | 13.976503                            | 403              | 15.866284                            |
| 308              | 12.126093                            | 356              | 14.015874                            | 404              | 15.905655                            |

| Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch |
|------------------|--------------------------------------|------------------|--------------------------------------|------------------|--------------------------------------|
| 405              | 15.945025                            | 453              | 17.834806                            | 501              | 19.724586                            |
| 406              | 15.984395                            | 454              | 17.874176                            | 502              | 19.768957                            |
| 407              | 16.023766                            | 455              | 17.918547                            | 503              | 19.808327                            |
| 408              | 16.063136                            | 456              | 17.952917                            | 504              | 19.842698                            |
| 409              | 16.102507                            | 457              | 17.992287                            | 505              | 19.882068                            |
| 410              | 16.141877                            | 458              | 18.031658                            | 506              | 19.921439                            |
| 411              | 16.181248                            | 459              | 18.071028                            | 507              | 19.960809                            |
| 412              | 16.220618                            | 460              | 18.110399                            | 508              | 20.000179                            |
| 413              | 16.259988                            | 461              | 18.149769                            | 509              | 20.039550                            |
| 414              | 16.299359                            | 462              | 18.189140                            | 510              | 20.078920                            |
| 415              | 16.338729                            | 463              | 18.228510                            | 511              | 20.118291                            |
| 416              | 16.378100                            | 464              | 18.267880                            | 512              | 20.157661                            |
| 417              | 16.417470                            | 465              | 18.307251                            | 513              | 20.197032                            |
| 418              | 16.456841                            | 466              | 18.346621                            | 514              | 20.236402                            |
| 419              | 16.496211                            | 467              | 18.385992                            | 515              | 20.275773                            |
| 420              | 16.535581                            | 468              | 18.425362                            | 516              | 20.315143                            |
| 421              | 16.574952                            | 469              | 18.464733                            | 517              | 20.354513                            |
| 422              | 16.614322                            | 470              | 18.504103                            | 518              | 20.393884                            |
| 423              | 16.653693                            | 471              | 18.543474                            | 519              | 20.433254                            |
| 424              | 16.693063                            | 472              | 18.582844                            | 520              | 20.472625                            |
| 425              | 16.732434                            | 473              | 18.622214                            | 521              | 20.511995                            |
| 426              | 16.771804                            | 474              | 18.661585                            | 522              | 20.551366                            |
| 427              | 16.811175                            | 475              | 18.700955                            | 523              | 20.590736                            |
| 428              | 16.850545                            | 476              | 18.740326                            | 524              | 20.630106                            |
| 429              | 16.889915                            | 477              | 18.779696                            | 525              | 20.669477                            |
| 430              | 16.929286                            | 478              | 18.819067                            | 526              | 20.708847                            |
| 431              | 16.968656                            | 479              | 18.858437                            | 527              | 20.748218                            |
| 432              | 17.008027                            | 480              | 18.897807                            | 528              | 20.787588                            |
| 433              | 17.047397                            | 481              | 18.937178                            | 529              | 20.826959                            |
| 434              | 17.086768                            | 482              | 18.976548                            | 530              | 20.866329                            |
| 435              | 17.126138                            | 483              | 19.015919                            | 531              | 20.905699                            |
| 436              | 17.165508                            | 484              | 19.055289                            | 532              | 20.945070                            |
| 437              | 17.204879                            | 485              | 19.094660                            | 533              | 20.984440                            |
| 438              | 17.244249                            | 486              | 19.134030                            | 534              | 21.023811                            |
| 439              | 17.283620                            | 487              | 19.173400                            | 535              | 21.063181                            |
| 440              | 17.322990                            | 488              | 19.212771                            | 536              | 21.102552                            |
| 441              | 17.362361                            | 489              | 19.252141                            | 537              | 21.141922                            |
| 442              | 17.401731                            | 490              | 19.291512                            | 538              | 21.181292                            |
| 443              | 17.441101                            | 491              | 19.330882                            | 539              | 21.220663                            |
| 444              | 17.480472                            | 492              | 19.370253                            | 540              | 21.260033                            |
| 445              | 17.519842                            | 493              | 19.409623                            | 541              | 21.299404                            |
| 446              | 17.559213                            | 494              | 19.448993                            | 542              | 21.338774                            |
| 447              | 17.598583                            | 495              | 19.488364                            | 543              | 21.378145                            |
| 448              | 17.637954                            | 496              | 19.527734                            | 544              | 21.417515                            |
| 449              | 17.677324                            | 497              | 19.567095                            | 545              | 21.456886                            |
| 450              | 17.716694                            | 498              | 19.606465                            | 546              | 21.496256                            |
| 451              | 17.756065                            | 499              | 19.645836                            | 547              | 21.535626                            |
| 452              | 17.795435                            | 500              | 19.685216                            | 548              | 21.574997                            |

| Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch |
|------------------|--------------------------------------|------------------|--------------------------------------|------------------|--------------------------------------|
| 837              | 32.958052                            | 885              | 34.842832                            | 933              | 36.732613                            |
| 838              | 32.992422                            | 886              | 34.882203                            | 934              | 36.771984                            |
| 839              | 33.031792                            | 887              | 34.921573                            | 935              | 36.811354                            |
| 840              | 33.071163                            | 888              | 34.960944                            | 936              | 36.850724                            |
| 841              | 33.110533                            | 889              | 35.000314                            | 937              | 36.890095                            |
| 842              | 33.149904                            | 890              | 35.039684                            | 938              | 36.929465                            |
| 843              | 33.189274                            | 891              | 35.079055                            | 939              | 36.968836                            |
| 844              | 33.228645                            | 892              | 35.118425                            | 940              | 37.008206                            |
| 845              | 33.268015                            | 893              | 35.157796                            | 941              | 37.047576                            |
| 846              | 33.307385                            | 894              | 35.197166                            | 942              | 37.086947                            |
| 847              | 33.346756                            | 895              | 35.236536                            | 943              | 37.126317                            |
| 848              | 33.386126                            | 896              | 35.275907                            | 944              | 37.165688                            |
| 849              | 33.425497                            | 897              | 35.315277                            | 945              | 37.205058                            |
| 850              | 33.464867                            | 898              | 35.354648                            | 946              | 37.244429                            |
| 851              | 33.504238                            | 899              | 35.394018                            | 947              | 37.283799                            |
| 852              | 33.543608                            | 900              | 35.433389                            | 948              | 37.323170                            |
| 853              | 33.582979                            | 901              | 35.472759                            | 949              | 37.362540                            |
| 854              | 33.622349                            | 902              | 35.512130                            | 950              | 37.410910                            |
| 855              | 33.661719                            | 903              | 35.551500                            | 951              | 37.441281                            |
| 856              | 33.701090                            | 904              | 35.590971                            | 952              | 37.480651                            |
| 857              | 33.740460                            | 905              | 35.630241                            | 953              | 37.520022                            |
| 858              | 33.779831                            | 906              | 35.669611                            | 954              | 37.559392                            |
| 859              | 33.819201                            | 907              | 35.708982                            | 955              | 37.598765                            |
| 860              | 33.858572                            | 908              | 35.748352                            | 956              | 37.638135                            |
| 861              | 33.897942                            | 909              | 35.787723                            | 957              | 37.677508                            |
| 862              | 33.937312                            | 910              | 35.827093                            | 958              | 37.716874                            |
| 863              | 33.976683                            | 911              | 35.866464                            | 959              | 37.756244                            |
| 864              | 34.016053                            | 912              | 35.905834                            | 960              | 37.795615                            |
| 865              | 34.055424                            | 913              | 35.945204                            | 961              | 37.834985                            |
| 866              | 34.094794                            | 914              | 35.984575                            | 962              | 37.874356                            |
| 867              | 34.134165                            | 915              | 36.023945                            | 963              | 37.913726                            |
| 868              | 34.173535                            | 916              | 36.063316                            | 964              | 37.953096                            |
| 869              | 34.212905                            | 917              | 36.102686                            | 965              | 37.992467                            |
| 870              | 34.252276                            | 918              | 36.142057                            | 966              | 38.031837                            |
| 871              | 34.291646                            | 919              | 36.181427                            | 967              | 38.071208                            |
| 872              | 34.331017                            | 920              | 36.220797                            | 968              | 38.110578                            |
| 873              | 34.370387                            | 921              | 36.260168                            | 969              | 38.149949                            |
| 874              | 34.409758                            | 922              | 36.299538                            | 970              | 38.189319                            |
| 875              | 34.449128                            | 923              | 36.338909                            | 971              | 38.228689                            |
| 876              | 34.448498                            | 924              | 36.378279                            | 972              | 38.268060                            |
| 877              | 34.527869                            | 925              | 36.417650                            | 973              | 38.307430                            |
| 878              | 34.567239                            | 926              | 36.457020                            | 974              | 38.346801                            |
| 879              | 34.606610                            | 927              | 36.496390                            | 975              | 38.386171                            |
| 880              | 34.645980                            | 928              | 36.535761                            | 976              | 38.425542                            |
| 881              | 34.685351                            | 929              | 36.575131                            | 977              | 38.464912                            |
| 882              | 34.724721                            | 930              | 36.614502                            | 978              | 38.504283                            |
| 883              | 34.764091                            | 931              | 36.653872                            | 979              | 38.543653                            |
| 884              | 34.803462                            | 932              | 36.693243                            | 980              | 38.583023                            |

| Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch | Milli-<br>metres | Inches and<br>Decimals<br>of an Inch |
|------------------|--------------------------------------|------------------|--------------------------------------|------------------|--------------------------------------|
| 981              | 38.622394                            | 988              | 38.897987                            | 995              | 39.178580                            |
| 982              | 38.661764                            | 989              | 38.937857                            | 996              | 39.212950                            |
| 983              | 38.701135                            | 990              | 38.976728                            | 997              | 39.252321                            |
| 984              | 38.740505                            | 991              | 39.016098                            | 998              | 39.291691                            |
| 985              | 38.779876                            | 992              | 39.055469                            | 999              | 39.331062                            |
| 986              | 38.819246                            | 993              | 39.094839                            | 1000             | 39.370432                            |
| 987              | 38.858616                            | 994              | 39.134209                            |                  |                                      |

TABLE GIVING THE ENGLISH EQUIVALENTS OF METRES IN  
INCHES AND DECIMALS OF AN INCH.

| Metres | Inches and<br>Decimals<br>of an Inch | Metres | Inches and<br>Decimals<br>of an Inch | Metres | Inches and<br>Decimals<br>of an Inch |
|--------|--------------------------------------|--------|--------------------------------------|--------|--------------------------------------|
| 1      | 39.370432                            | 34     | 1338.594687                          | 67     | 2637.818941                          |
| 2      | 78.740864                            | 35     | 1377.965119                          | 68     | 2677.189373                          |
| 3      | 118.111296                           | 36     | 1417.335551                          | 69     | 2716.559805                          |
| 4      | 157.481728                           | 37     | 1456.705983                          | 70     | 2755.930237                          |
| 5      | 196.852160                           | 38     | 1496.076415                          | 71     | 2795.300669                          |
| 6      | 236.222592                           | 39     | 1535.446846                          | 72     | 2834.671101                          |
| 7      | 275.593024                           | 40     | 1574.817278                          | 73     | 2874.041533                          |
| 8      | 314.963456                           | 41     | 1614.187710                          | 74     | 2913.411965                          |
| 9      | 354.333888                           | 42     | 1653.558142                          | 75     | 2952.782397                          |
| 10     | 393.704320                           | 43     | 1692.928574                          | 76     | 2992.152829                          |
| 11     | 433.074752                           | 44     | 1732.299006                          | 77     | 3031.523261                          |
| 12     | 472.445184                           | 45     | 1771.669438                          | 78     | 3070.893693                          |
| 13     | 511.815616                           | 46     | 1811.039870                          | 79     | 3110.264125                          |
| 14     | 551.186047                           | 47     | 1850.410302                          | 80     | 3149.634557                          |
| 15     | 590.556479                           | 48     | 1889.780734                          | 81     | 3189.004989                          |
| 16     | 629.926911                           | 49     | 1929.151166                          | 82     | 3228.375421                          |
| 17     | 669.297343                           | 50     | 1968.521598                          | 83     | 3267.745853                          |
| 18     | 708.667775                           | 51     | 2007.892030                          | 84     | 3307.116285                          |
| 19     | 748.038207                           | 52     | 2047.262462                          | 85     | 3346.486717                          |
| 20     | 787.408639                           | 53     | 2086.632894                          | 86     | 3385.857149                          |
| 21     | 826.779071                           | 54     | 2126.003326                          | 87     | 3425.227581                          |
| 22     | 866.149503                           | 55     | 2165.373758                          | 88     | 3464.598013                          |
| 23     | 905.519935                           | 56     | 2204.744190                          | 89     | 3503.968444                          |
| 24     | 944.890367                           | 57     | 2244.114622                          | 90     | 3543.338876                          |
| 25     | 984.260799                           | 58     | 2283.485054                          | 91     | 3582.709308                          |
| 26     | 1023.631231                          | 59     | 2322.855486                          | 92     | 3622.079740                          |
| 27     | 1063.001663                          | 60     | 2362.225918                          | 93     | 3661.450172                          |
| 28     | 1102.372095                          | 61     | 2401.596350                          | 94     | 3700.820604                          |
| 29     | 1141.742527                          | 62     | 2440.966782                          | 95     | 3740.191036                          |
| 30     | 1181.112959                          | 63     | 2480.337214                          | 96     | 3779.561468                          |
| 31     | 1220.483391                          | 64     | 2519.707645                          | 97     | 3818.931900                          |
| 32     | 1259.853823                          | 65     | 2559.078077                          | 98     | 3858.302332                          |
| 33     | 1299.224255                          | 66     | 2598.448509                          | 99     | 3897.672764                          |

TABLE GIVING THE EQUIVALENTS IN MILLIMETRES  
OF THE DIVISIONS OF THE INCH.

| Divisions of the Inch |                |                |                 | Millimetres | Divisions of the Inch |                |                |                 | Millimetres |
|-----------------------|----------------|----------------|-----------------|-------------|-----------------------|----------------|----------------|-----------------|-------------|
| ...                   | ...            | ...            | $\frac{1}{128}$ | ·198436     | $\frac{8}{128}$       | ...            | $\frac{1}{8}$  | $\frac{1}{128}$ | 8·532786    |
| ...                   | ...            | $\frac{1}{64}$ | ...             | ·896871     | $\frac{16}{128}$      | $\frac{1}{32}$ | ...            | ...             | 8·731172    |
| ...                   | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | ·595307     | $\frac{24}{128}$      | $\frac{3}{32}$ | ...            | $\frac{1}{128}$ | 8·929007    |
| ...                   | $\frac{1}{32}$ | ...            | ...             | ·793743     | $\frac{32}{128}$      | $\frac{1}{8}$  | $\frac{1}{64}$ | ...             | 9·128043    |
| ...                   | $\frac{1}{16}$ | ...            | $\frac{1}{128}$ | ·992179     | $\frac{40}{128}$      | $\frac{5}{32}$ | $\frac{1}{32}$ | $\frac{1}{128}$ | 9·326479    |
| ...                   | $\frac{3}{32}$ | $\frac{1}{64}$ | ...             | 1·190614    | ...                   | ...            | ...            | ...             | 9·524915    |
| ...                   | $\frac{1}{8}$  | $\frac{1}{32}$ | $\frac{1}{128}$ | 1·389050    | ...                   | ...            | ...            | $\frac{1}{128}$ | 9·723350    |
| $\frac{1}{16}$        | ...            | ...            | ...             | 1·587486    | ...                   | ...            | $\frac{1}{64}$ | ...             | 9·921786    |
| $\frac{1}{8}$         | ...            | ...            | $\frac{1}{128}$ | 1·785921    | ...                   | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 10·120222   |
| $\frac{1}{4}$         | ...            | $\frac{1}{64}$ | ...             | 1·984357    | ...                   | $\frac{1}{16}$ | ...            | ...             | 10·318657   |
| $\frac{1}{2}$         | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 2·182793    | ...                   | $\frac{1}{8}$  | ...            | $\frac{1}{128}$ | 10·517093   |
| $\frac{3}{4}$         | $\frac{1}{32}$ | ...            | ...             | 2·385129    | ...                   | $\frac{3}{32}$ | $\frac{1}{64}$ | ...             | 10·715529   |
| $\frac{7}{8}$         | $\frac{1}{16}$ | ...            | $\frac{1}{128}$ | 2·579664    | ...                   | $\frac{1}{2}$  | $\frac{1}{32}$ | $\frac{1}{128}$ | 10·913965   |
| ...                   | $\frac{3}{8}$  | $\frac{1}{64}$ | ...             | 2·778100    | $\frac{1}{8}$         | ...            | ...            | ...             | 11·112400   |
| $\frac{1}{16}$        | $\frac{1}{16}$ | $\frac{1}{32}$ | $\frac{1}{128}$ | 2·976536    | $\frac{1}{4}$         | ...            | ...            | $\frac{1}{128}$ | 11·310836   |
| $\frac{1}{8}$         | ...            | ...            | ...             | 3·174972    | $\frac{1}{2}$         | ...            | $\frac{1}{64}$ | ...             | 11·509272   |
| $\frac{3}{8}$         | ...            | ...            | $\frac{1}{128}$ | 3·373407    | $\frac{3}{4}$         | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 11·707707   |
| $\frac{1}{2}$         | ...            | $\frac{1}{64}$ | ...             | 3·571843    | $\frac{5}{8}$         | $\frac{1}{32}$ | ...            | ...             | 11·906143   |
| $\frac{3}{4}$         | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 3·770279    | $\frac{7}{8}$         | $\frac{1}{16}$ | ...            | $\frac{1}{128}$ | 12·104579   |
| $\frac{7}{8}$         | $\frac{1}{16}$ | ...            | ...             | 3·968714    | $\frac{15}{16}$       | $\frac{1}{8}$  | $\frac{1}{64}$ | ...             | 12·303015   |
| ...                   | $\frac{3}{8}$  | ...            | $\frac{1}{128}$ | 4·167150    | $\frac{1}{8}$         | $\frac{1}{16}$ | $\frac{1}{32}$ | $\frac{1}{128}$ | 12·501450   |
| $\frac{1}{16}$        | $\frac{1}{8}$  | $\frac{1}{32}$ | ...             | 4·365586    | $\frac{1}{4}$         | ...            | ...            | ...             | 12·699886   |
| $\frac{1}{8}$         | $\frac{1}{4}$  | $\frac{1}{16}$ | $\frac{1}{128}$ | 4·564022    | $\frac{3}{8}$         | ...            | ...            | $\frac{1}{128}$ | 12·898322   |
| $\frac{3}{16}$        | ...            | ...            | ...             | 4·762457    | $\frac{1}{2}$         | ...            | $\frac{1}{64}$ | ...             | 13·096757   |
| $\frac{1}{4}$         | ...            | ...            | $\frac{1}{128}$ | 4·960893    | $\frac{5}{8}$         | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 13·295193   |
| $\frac{5}{16}$        | ...            | $\frac{1}{64}$ | ...             | 5·159329    | $\frac{3}{4}$         | $\frac{1}{16}$ | ...            | ...             | 13·493629   |
| $\frac{3}{8}$         | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 5·357764    | $\frac{7}{8}$         | $\frac{1}{8}$  | ...            | $\frac{1}{128}$ | 13·692065   |
| $\frac{1}{2}$         | $\frac{1}{16}$ | ...            | ...             | 5·556200    | $\frac{15}{16}$       | $\frac{1}{4}$  | $\frac{1}{64}$ | ...             | 13·890500   |
| $\frac{5}{8}$         | $\frac{1}{8}$  | ...            | $\frac{1}{128}$ | 5·754636    | $\frac{1}{8}$         | $\frac{1}{8}$  | $\frac{1}{32}$ | $\frac{1}{128}$ | 14·088936   |
| $\frac{3}{4}$         | $\frac{1}{4}$  | $\frac{1}{16}$ | ...             | 5·953072    | $\frac{3}{8}$         | ...            | ...            | ...             | 14·287372   |
| $\frac{7}{8}$         | $\frac{3}{8}$  | $\frac{1}{32}$ | $\frac{1}{128}$ | 6·151508    | $\frac{1}{2}$         | ...            | ...            | $\frac{1}{128}$ | 14·485808   |
| ...                   | $\frac{1}{2}$  | ...            | ...             | 6·349943    | $\frac{5}{8}$         | ...            | $\frac{1}{64}$ | ...             | 14·684243   |
| $\frac{1}{16}$        | ...            | ...            | $\frac{1}{128}$ | 6·548379    | $\frac{3}{4}$         | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 14·882679   |
| $\frac{1}{8}$         | ...            | $\frac{1}{64}$ | ...             | 6·746814    | $\frac{7}{8}$         | $\frac{1}{8}$  | ...            | ...             | 15·081115   |
| $\frac{3}{16}$        | ...            | $\frac{1}{32}$ | $\frac{1}{128}$ | 6·945250    | $\frac{15}{16}$       | $\frac{3}{8}$  | ...            | $\frac{1}{128}$ | 15·279550   |
| $\frac{1}{4}$         | $\frac{1}{8}$  | ...            | ...             | 7·143686    | $\frac{1}{8}$         | $\frac{1}{8}$  | $\frac{1}{32}$ | ...             | 15·477986   |
| $\frac{5}{16}$        | $\frac{1}{4}$  | ...            | $\frac{1}{128}$ | 7·342122    | $\frac{3}{8}$         | $\frac{1}{4}$  | $\frac{1}{64}$ | $\frac{1}{128}$ | 15·676422   |
| $\frac{3}{8}$         | $\frac{3}{8}$  | $\frac{1}{16}$ | ...             | 7·540557    | $\frac{1}{2}$         | ...            | ...            | ...             | 15·874858   |
| $\frac{7}{16}$        | $\frac{7}{16}$ | $\frac{1}{32}$ | $\frac{1}{128}$ | 7·738993    | $\frac{5}{8}$         | ...            | ...            | $\frac{1}{128}$ | 16·073293   |
| $\frac{1}{2}$         | $\frac{1}{2}$  | $\frac{1}{64}$ | ...             | 7·937429    | $\frac{3}{4}$         | ...            | $\frac{1}{32}$ | ...             | 16·271729   |
| $\frac{5}{8}$         | ...            | ...            | $\frac{1}{128}$ | 8·135865    | $\frac{7}{8}$         | ...            | $\frac{1}{64}$ | $\frac{1}{128}$ | 16·470165   |
| $\frac{3}{4}$         | ...            | ...            | ...             | 8·334300    | $\frac{15}{16}$       | ...            | $\frac{1}{32}$ | ...             | 16·668600   |

| Divisions of the Inch |                |                |                 | Millimetres | Divisions of the Inch |                |                |                 | Millimetres |
|-----------------------|----------------|----------------|-----------------|-------------|-----------------------|----------------|----------------|-----------------|-------------|
| $\frac{5}{16}$        | $\frac{1}{32}$ | ...            | $\frac{1}{128}$ | 16.867036   | $\frac{13}{16}$       | ...            | $\frac{1}{64}$ | $\frac{1}{128}$ | 21.232622   |
| $\frac{9}{16}$        | $\frac{1}{32}$ | $\frac{1}{64}$ | ...             | 17.065472   | $\frac{13}{16}$       | $\frac{1}{32}$ | ...            | ...             | 21.431058   |
| $\frac{5}{8}$         | $\frac{1}{32}$ | $\frac{1}{64}$ | $\frac{1}{128}$ | 17.263908   | $\frac{13}{16}$       | $\frac{1}{32}$ | ...            | $\frac{1}{128}$ | 21.629493   |
| $\frac{11}{16}$       | ...            | ...            | ...             | 17.462343   | $\frac{13}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | ...             | 21.827929   |
| $\frac{11}{16}$       | ...            | ...            | $\frac{1}{128}$ | 17.660779   | $\frac{13}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | $\frac{1}{128}$ | 22.026365   |
| $\frac{11}{16}$       | ...            | $\frac{1}{64}$ | ...             | 17.859215   | $\frac{13}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | $\frac{1}{128}$ | 22.224801   |
| $\frac{11}{16}$       | ...            | $\frac{1}{64}$ | $\frac{1}{128}$ | 18.057650   | $\frac{13}{16}$       | ...            | ...            | ...             | 22.423236   |
| $\frac{11}{16}$       | $\frac{1}{32}$ | ...            | ...             | 18.256086   | $\frac{13}{16}$       | ...            | $\frac{1}{64}$ | ...             | 22.621672   |
| $\frac{11}{16}$       | $\frac{1}{32}$ | ...            | $\frac{1}{128}$ | 18.454522   | $\frac{13}{16}$       | ...            | $\frac{1}{64}$ | $\frac{1}{128}$ | 22.820108   |
| $\frac{11}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | ...             | 18.652958   | $\frac{13}{16}$       | $\frac{1}{32}$ | ...            | ...             | 23.018543   |
| $\frac{11}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | $\frac{1}{128}$ | 18.851393   | $\frac{13}{16}$       | $\frac{1}{32}$ | ...            | $\frac{1}{128}$ | 23.216979   |
| $\frac{3}{4}$         | ...            | ...            | ...             | 19.049829   | $\frac{13}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | ...             | 23.415415   |
| $\frac{3}{4}$         | ...            | ...            | $\frac{1}{128}$ | 19.248265   | $\frac{13}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | $\frac{1}{128}$ | 23.613851   |
| $\frac{3}{4}$         | ...            | $\frac{1}{64}$ | ...             | 19.446701   | $\frac{15}{16}$       | ...            | ...            | ...             | 23.812286   |
| $\frac{3}{4}$         | ...            | $\frac{1}{64}$ | $\frac{1}{128}$ | 19.645136   | $\frac{15}{16}$       | ...            | ...            | $\frac{1}{128}$ | 24.010722   |
| $\frac{3}{4}$         | $\frac{1}{32}$ | ...            | ...             | 19.843572   | $\frac{15}{16}$       | ...            | $\frac{1}{64}$ | ...             | 24.209158   |
| $\frac{3}{4}$         | $\frac{1}{32}$ | ...            | $\frac{1}{128}$ | 20.042008   | $\frac{15}{16}$       | ...            | $\frac{1}{64}$ | $\frac{1}{128}$ | 24.407594   |
| $\frac{3}{4}$         | $\frac{1}{32}$ | $\frac{1}{64}$ | ...             | 20.240443   | $\frac{15}{16}$       | $\frac{1}{32}$ | ...            | ...             | 24.606029   |
| $\frac{3}{4}$         | $\frac{1}{32}$ | $\frac{1}{64}$ | $\frac{1}{128}$ | 20.438879   | $\frac{15}{16}$       | $\frac{1}{32}$ | ...            | $\frac{1}{128}$ | 24.804465   |
| $\frac{13}{16}$       | ...            | ...            | ...             | 20.637315   | $\frac{15}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | ...             | 25.002901   |
| $\frac{13}{16}$       | ...            | ...            | $\frac{1}{128}$ | 20.835751   | $\frac{15}{16}$       | $\frac{1}{32}$ | $\frac{1}{64}$ | $\frac{1}{128}$ | 25.201336   |
| $\frac{13}{16}$       | ...            | $\frac{1}{64}$ | ...             | 21.034186   | 1                     | ...            | ...            | ...             | 25.399772   |

TABLE GIVING THE EQUIVALENTS IN MILLIMETRES OF THE DIVISIONS OF THE FOOT.

| In. | Millimetres | In. | Millimetres | In. | Millimetres | In. | Millimetres |
|-----|-------------|-----|-------------|-----|-------------|-----|-------------|
| 1   | 25.39977    | 10  | 253.99772   | 19  | 482.59567   | 28  | 711.19362   |
| 2   | 50.79954    | 11  | 279.39749   | 20  | 507.99544   | 29  | 736.59339   |
| 3   | 76.19932    | 12  | 304.79727   | 21  | 533.39521   | 30  | 761.99316   |
| 4   | 101.59909   | 13  | 330.19704   | 22  | 558.79499   | 31  | 787.39294   |
| 5   | 126.99886   | 14  | 355.59681   | 23  | 584.19476   | 32  | 812.79271   |
| 6   | 152.39863   | 15  | 380.99658   | 24  | 609.59453   | 33  | 838.19248   |
| 7   | 177.79840   | 16  | 406.39635   | 25  | 634.99430   | 34  | 863.59225   |
| 8   | 203.19818   | 17  | 431.79613   | 26  | 660.39408   | 35  | 888.99202   |
| 9   | 228.59795   | 18  | 457.19590   | 27  | 685.78385   | 36  | 914.39180   |

TABLE GIVING THE EQUIVALENTS OF LINEAL FEET IN METRES.

| Ft. | Metres    | Ft. | Metres    | Ft. | Metres    | Ft. | Metres    |
|-----|-----------|-----|-----------|-----|-----------|-----|-----------|
| 1   | .3047973  | 6   | 1.8287840 | 11  | 3.3527706 | 16  | 4.8767573 |
| 2   | .6095947  | 7   | 2.1335813 | 12  | 3.6755680 | 17  | 5.1815546 |
| 3   | .9143920  | 8   | 2.4383786 | 13  | 3.9623653 | 18  | 5.4863519 |
| 4   | 1.2191893 | 9   | 2.7431760 | 14  | 4.2671626 | 19  | 5.7911493 |
| 5   | 1.5239867 | 10  | 3.0479733 | 15  | 4.5719600 | 20  | 6.0959466 |



# 134 EQUIVALENTS OF ENGLISH AND METRICAL WEIGHTS.

TABLE GIVING THE EQUIVALENTS OF AVOIR. OZ. IN FRENCH KILOGRAMS.

| Oz. | Kilograms  | Oz. | Kilograms  | Oz. | Kilograms  | Oz. | Kilograms  |
|-----|------------|-----|------------|-----|------------|-----|------------|
| 1   | ·028349541 | 5   | ·141747704 | 9   | ·255145867 | 13  | ·368544030 |
| 2   | ·056699082 | 6   | ·170097245 | 10  | ·283495408 | 14  | ·396893571 |
| 3   | ·085048622 | 7   | ·198446785 | 11  | ·311844948 | 15  | ·425243112 |
| 4   | ·113398163 | 8   | ·226796326 | 12  | ·340194489 | 16  | ·453592652 |

TABLE GIVING THE EQUIVALENTS OF AVOIR. LBS. IN FRENCH KILOGRAMS.

| Lbs. | Kilograms  | Lbs. | Kilograms  | Lbs. | Kilograms  | bs. | Kilograms   |
|------|------------|------|------------|------|------------|-----|-------------|
| 1    | ·45359265  | 8    | 3·62874122 | 15   | 6·80388978 | 22  | 9·97903835  |
| 2    | ·90718530  | 9    | 4·08233387 | 16   | 7·25748243 | 23  | 10·43263100 |
| 3    | 1·36077796 | 10   | 4·53592652 | 17   | 7·71107509 | 24  | 10·88622365 |
| 4    | 1·81437061 | 11   | 4·98951917 | 18   | 8·16466774 | 25  | 11·33981631 |
| 5    | 2·26796326 | 12   | 5·44311183 | 19   | 8·61826039 | 26  | 11·79340896 |
| 6    | 2·72155591 | 13   | 5·89670448 | 20   | 9·07185305 | 27  | 12·24700161 |
| 7    | 3·17514857 | 14   | 6·35029713 | 21   | 9·52544570 | 28  | 12·70059426 |

TABLE GIVING THE EQUIVALENTS OF QUARTERS IN FRENCH KILOGRAMS.

| Qr. | Kilograms   | Qrs. | Kilograms   | Qrs. | Kilograms   | Qrs. | Kilograms   |
|-----|-------------|------|-------------|------|-------------|------|-------------|
| 1   | 12·70059426 | 2    | 25·40118853 | 3    | 38·10178279 | 4    | 50·80237705 |

TABLE GIVING THE EQUIVALENTS OF CWTs. IN FRENCH KILOGRAMS.

| Cwt | Kilograms    | Cwt | Kilograms    | Cwt | Kilograms    | Cwt | Kilograms    |
|-----|--------------|-----|--------------|-----|--------------|-----|--------------|
| 1   | 50·80237705  | 6   | 304·81426231 | 11  | 558·82614757 | 16  | 812·83803283 |
| 2   | 101·60475410 | 7   | 355·61668936 | 12  | 609·62852462 | 17  | 863·64040988 |
| 3   | 152·40713116 | 8   | 406·41901642 | 13  | 660·43090168 | 18  | 914·44278694 |
| 4   | 203·20950821 | 9   | 457·22139347 | 14  | 711·23327873 | 19  | 965·24516399 |
| 5   | 254·01188526 | 10  | 508·02377052 | 15  | 762·03565578 | 20  | 1016·0475411 |

TABLE GIVING THE EQUIVALENTS OF TONS IN FRENCH KILOGRAMS.

| Tons | Kilograms  | Tons | Kilograms  | Tons | Kilograms  | Tons | Kilograms  |
|------|------------|------|------------|------|------------|------|------------|
| 1    | 1016·04754 | 20   | 20320·9508 | 300  | 304814·262 | 1300 | 1320861·80 |
| 2    | 2032·09508 | 30   | 30481·4262 | 400  | 406419·016 | 1400 | 1422466·56 |
| 3    | 3048·14262 | 40   | 40641·9016 | 500  | 508023·771 | 1500 | 1524071·31 |
| 4    | 4064·19016 | 50   | 50802·3771 | 600  | 609628·525 | 1600 | 1625676·07 |
| 5    | 5080·23771 | 60   | 60962·8525 | 700  | 711233·279 | 1700 | 1727280·82 |
| 6    | 6096·28525 | 70   | 71123·3279 | 800  | 812838·033 | 1800 | 1828885·57 |
| 7    | 7112·33279 | 80   | 81283·8033 | 900  | 914442·787 | 1900 | 1930490·33 |
| 8    | 8128·33033 | 90   | 91444·2787 | 1000 | 1016047·54 | 2000 | 2032095·08 |
| 9    | 9144·42787 | 100  | 101604·754 | 1100 | 1117652·30 | 3000 | 3048142·62 |
| 10   | 10160·4754 | 200  | 203209·508 | 1200 | 1219257·05 | 4000 | 4064190·16 |

TABLE GIVING THE EQUIVALENTS OF KILOGRAMS IN AVOIRDUPOIS POUNDS AND TONS.

| Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       |
|--------|-------------|-----------|--------|-------------|-----------|--------|-------------|-----------|--------|-------------|-----------|
| 1      | 2.20462     | .00098421 | 26     | 57.32015    | .02558935 | 51     | 112.43568   | .05019450 | 76     | 167.55122   | .07479965 |
| 2      | 4.40924     | .00196841 | 27     | 59.52477    | .02657356 | 52     | 114.64031   | .05117871 | 77     | 169.75584   | .07578386 |
| 3      | 6.61386     | .00295262 | 28     | 61.72940    | .02755777 | 53     | 116.84493   | .05216291 | 78     | 171.96046   | .07676806 |
| 4      | 8.81849     | .00393682 | 29     | 63.93402    | .02854197 | 54     | 119.04955   | .05314712 | 79     | 174.16508   | .07775227 |
| 5      | 11.02311    | .00492103 | 30     | 66.13864    | .02952618 | 55     | 121.25417   | .05413133 | 80     | 176.36970   | .07873647 |
| 6      | 13.22773    | .00590524 | 31     | 68.34326    | .03051038 | 56     | 123.45879   | .05511553 | 81     | 178.57432   | .07972068 |
| 7      | 15.43235    | .00688944 | 32     | 70.54788    | .03149459 | 57     | 125.66311   | .05609974 | 82     | 180.77894   | .08070489 |
| 8      | 17.63697    | .00787365 | 33     | 72.75250    | .03247880 | 58     | 127.86803   | .05708394 | 83     | 182.98356   | .08168909 |
| 9      | 19.84159    | .00885785 | 34     | 74.95712    | .03346300 | 59     | 130.07265   | .05806815 | 84     | 185.18819   | .08267380 |
| 10     | 22.04621    | .00984206 | 35     | 77.16174    | .03444721 | 60     | 132.27728   | .05905235 | 85     | 187.39281   | .08365750 |
| 11     | 24.25083    | .01082627 | 36     | 79.36637    | .03543141 | 61     | 134.48190   | .06003656 | 86     | 189.59743   | .08464171 |
| 12     | 26.45555    | .01181047 | 37     | 81.57099    | .03641562 | 62     | 136.68652   | .06102077 | 87     | 191.80205   | .08562591 |
| 13     | 28.66008    | .01279468 | 38     | 83.77561    | .03739982 | 63     | 138.89114   | .06200497 | 88     | 194.00667   | .08661012 |
| 14     | 30.86470    | .01377888 | 39     | 85.98023    | .03838403 | 64     | 141.09576   | .06298918 | 89     | 196.21129   | .08759433 |
| 15     | 33.06932    | .01476309 | 40     | 88.18485    | .03936824 | 65     | 143.30038   | .06397338 | 90     | 198.41591   | .08857853 |
| 16     | 35.27394    | .01574729 | 41     | 90.38947    | .04035244 | 66     | 145.50500   | .06495759 | 91     | 200.62053   | .08956274 |
| 17     | 37.47856    | .01673150 | 42     | 92.59409    | .04133665 | 67     | 147.70962   | .06594180 | 92     | 202.82516   | .09054694 |
| 18     | 39.68318    | .01771571 | 43     | 94.79871    | .04232085 | 68     | 149.91425   | .06692600 | 93     | 205.02978   | .09153115 |
| 19     | 41.88780    | .01869991 | 44     | 97.00334    | .04330506 | 69     | 152.11887   | .06791021 | 94     | 207.23440   | .09251536 |
| 20     | 44.09243    | .01968412 | 45     | 99.20796    | .04428927 | 70     | 154.32349   | .06889441 | 95     | 209.43902   | .09349956 |
| 21     | 46.29705    | .02066832 | 46     | 101.41258   | .04527347 | 71     | 156.52811   | .06987862 | 96     | 211.64364   | .09448377 |
| 22     | 48.50167    | .02165253 | 47     | 103.61720   | .04625768 | 72     | 158.73273   | .07086283 | 97     | 213.84826   | .09546797 |
| 23     | 50.70629    | .02263674 | 48     | 105.82182   | .04724188 | 73     | 160.93735   | .07184703 | 98     | 216.05288   | .09645218 |
| 24     | 52.91091    | .02362094 | 49     | 108.02644   | .04822609 | 74     | 163.14197   | .07283124 | 99     | 218.25750   | .09743639 |
| 25     | 55.11553    | .02460515 | 50     | 110.23106   | .04921030 | 75     | 165.34659   | .07381544 | 100    | 220.46213   | .09842059 |

TABLE GIVING THE EQUIVALENTS OF KILOGRAMS IN AVOIRDUPOIS POUNDS AND TONS (concluded).

| Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       |
|--------|-------------|-----------|--------|-------------|-----------|--------|-------------|-----------|--------|-------------|-----------|
| 101    | 222.66675   | .09940480 | 126    | 277.78228   | .12400995 | 151    | 332.89781   | .14861509 | 176    | 388.01334   | .17322024 |
| 102    | 224.87137   | .10038900 | 127    | 279.98690   | .12499415 | 152    | 335.10243   | .14959930 | 177    | 390.21796   | .17420445 |
| 103    | 227.07599   | .10137321 | 128    | 282.29152   | .12597836 | 153    | 337.30705   | .15058351 | 178    | 392.42258   | .17518865 |
| 104    | 229.28061   | .10235742 | 129    | 284.49614   | .12696256 | 154    | 339.51167   | .15156771 | 179    | 394.62720   | .17617286 |
| 105    | 231.48523   | .10334162 | 130    | 286.60076   | .12794677 | 155    | 341.71629   | .15255192 | 180    | 396.83183   | .17715706 |
| 106    | 233.68985   | .10432583 | 131    | 288.80538   | .12893097 | 156    | 343.92092   | .15353612 | 181    | 399.03645   | .17814127 |
| 107    | 235.89447   | .10531003 | 132    | 291.01001   | .12991518 | 157    | 346.12554   | .15452033 | 182    | 401.24107   | .17912548 |
| 108    | 238.09910   | .10629424 | 133    | 293.21463   | .13089939 | 158    | 348.33016   | .15550453 | 183    | 403.44569   | .18010968 |
| 109    | 240.30372   | .10727844 | 134    | 295.41925   | .13188359 | 159    | 350.53478   | .15648874 | 184    | 405.65031   | .18109389 |
| 110    | 242.50834   | .10826265 | 135    | 297.62387   | .13286780 | 160    | 352.73940   | .15747295 | 185    | 407.85493   | .18207809 |
| 111    | 244.71296   | .10924686 | 136    | 299.82849   | .13385200 | 161    | 354.94402   | .15845715 | 186    | 410.05955   | .18306230 |
| 112    | 246.91758   | .11023106 | 137    | 302.03311   | .13483621 | 162    | 357.14864   | .15944136 | 187    | 412.26417   | .18404651 |
| 113    | 249.12220   | .11121527 | 138    | 304.23773   | .13582042 | 163    | 359.35326   | .16042556 | 188    | 414.46880   | .18503071 |
| 114    | 251.32682   | .11219947 | 139    | 306.44235   | .13680462 | 164    | 361.55789   | .16140977 | 189    | 416.67342   | .18601492 |
| 115    | 253.53144   | .11318368 | 140    | 308.64698   | .13778883 | 165    | 363.76251   | .16239398 | 190    | 418.87804   | .18699912 |
| 116    | 255.73607   | .11416789 | 141    | 310.85160   | .13877303 | 166    | 365.96713   | .16337818 | 191    | 421.08266   | .18798333 |
| 117    | 257.94069   | .11515209 | 142    | 313.05622   | .13975724 | 167    | 368.17175   | .16436239 | 192    | 423.28728   | .18896754 |
| 118    | 260.14531   | .11613630 | 143    | 315.26084   | .14074145 | 168    | 370.37637   | .16534659 | 193    | 425.49190   | .18995174 |
| 119    | 262.34993   | .11712050 | 144    | 317.46546   | .14172565 | 169    | 372.58099   | .16633080 | 194    | 427.69652   | .19093595 |
| 120    | 264.55455   | .11810471 | 145    | 319.67008   | .14270986 | 170    | 374.78561   | .16731501 | 195    | 429.90114   | .19192015 |
| 121    | 266.75917   | .11908892 | 146    | 321.87470   | .14369406 | 171    | 376.99023   | .16829921 | 196    | 432.10577   | .19290436 |
| 122    | 268.96379   | .12007312 | 147    | 324.07932   | .14467827 | 172    | 379.19486   | .16928342 | 197    | 434.31039   | .19388857 |
| 123    | 271.16841   | .12105733 | 148    | 326.28395   | .14566248 | 173    | 381.39948   | .17026762 | 198    | 436.51501   | .19487277 |
| 124    | 273.37304   | .12204153 | 149    | 328.48857   | .14664668 | 174    | 383.60410   | .17125183 | 199    | 438.71963   | .19585698 |
| 125    | 275.57766   | .12302574 | 150    | 330.69319   | .14763089 | 175    | 385.80872   | .17223604 | 200    | 440.92425   | .19684118 |

TABLE OF THE DECIMAL EQUIVALENTS OF PARTS OF A TON.

| Lbs. | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton |
|------|----------------------|------|----------------------|------|----------------------|------|----------------------|
| 1    | ·000446              | 370  | ·165179              | 820  | ·366071              | 1270 | ·566964              |
| 2    | ·000893              | 380  | ·169643              | 830  | ·370536              | 1280 | ·571429              |
| 3    | ·001339              | 390  | ·174107              | 840  | ·375000              | 1290 | ·575893              |
| 4    | ·001786              | 400  | ·178571              | 850  | ·379464              | 1300 | ·580357              |
| 5    | ·002232              | 410  | ·183036              | 860  | ·383929              | 1310 | ·584821              |
| 6    | ·002679              | 420  | ·187500              | 870  | ·388393              | 1320 | ·589286              |
| 7    | ·003125              | 430  | ·191964              | 880  | ·392857              | 1330 | ·593750              |
| 8    | ·003571              | 440  | ·196429              | 890  | ·397321              | 1340 | ·598214              |
| 9    | ·004018              | 450  | ·200893              | 900  | ·401786              | 1350 | ·602679              |
| 10   | ·004464              | 460  | ·205357              | 910  | ·406250              | 1360 | ·607143              |
| 20   | ·008929              | 470  | ·209821              | 920  | ·410714              | 1370 | ·611607              |
| 30   | ·013393              | 480  | ·214286              | 930  | ·415179              | 1380 | ·616071              |
| 40   | ·017857              | 490  | ·218750              | 940  | ·419643              | 1390 | ·620536              |
| 50   | ·022321              | 500  | ·223214              | 950  | ·424107              | 1400 | ·625000              |
| 60   | ·026786              | 510  | ·227679              | 960  | ·428571              | 1410 | ·629464              |
| 70   | ·031250              | 520  | ·232143              | 970  | ·433036              | 1420 | ·633929              |
| 80   | ·035714              | 530  | ·236607              | 980  | ·437500              | 1430 | ·638393              |
| 90   | ·040179              | 540  | ·241071              | 990  | ·441964              | 1440 | ·642857              |
| 100  | ·044643              | 550  | ·245536              | 1000 | ·446429              | 1450 | ·647321              |
| 110  | ·049107              | 560  | ·250000              | 1010 | ·450893              | 1460 | ·651786              |
| 120  | ·053571              | 570  | ·254464              | 1020 | ·455357              | 1470 | ·656250              |
| 130  | ·058036              | 580  | ·258929              | 1030 | ·459821              | 1480 | ·660714              |
| 140  | ·062500              | 590  | ·263393              | 1040 | ·464286              | 1490 | ·665179              |
| 150  | ·066964              | 600  | ·267857              | 1050 | ·468750              | 1500 | ·669643              |
| 160  | ·071429              | 610  | ·272321              | 1060 | ·473214              | 1510 | ·674107              |
| 170  | ·075893              | 620  | ·276786              | 1070 | ·477679              | 1520 | ·678571              |
| 180  | ·080357              | 630  | ·281250              | 1080 | ·482143              | 1530 | ·683036              |
| 190  | ·084821              | 640  | ·285714              | 1090 | ·486607              | 1540 | ·687500              |
| 200  | ·089286              | 650  | ·290179              | 1100 | ·491071              | 1550 | ·691964              |
| 210  | ·093750              | 660  | ·294643              | 1110 | ·495536              | 1560 | ·696429              |
| 220  | ·098214              | 670  | ·299107              | 1120 | ·500000              | 1570 | ·700893              |
| 230  | ·102679              | 680  | ·303571              | 1130 | ·504464              | 1580 | ·705357              |
| 240  | ·107143              | 690  | ·308036              | 1140 | ·508929              | 1590 | ·709821              |
| 250  | ·111607              | 700  | ·312500              | 1150 | ·513393              | 1600 | ·714286              |
| 260  | ·116071              | 710  | ·316964              | 1160 | ·517857              | 1610 | ·718750              |
| 270  | ·120536              | 720  | ·321429              | 1170 | ·522321              | 1620 | ·723214              |
| 280  | ·125000              | 730  | ·325893              | 1180 | ·526786              | 1630 | ·727679              |
| 290  | ·129464              | 740  | ·330357              | 1190 | ·531250              | 1640 | ·732143              |
| 300  | ·133929              | 750  | ·334821              | 1200 | ·535714              | 1650 | ·736607              |
| 310  | ·138393              | 760  | ·339286              | 1210 | ·540179              | 1660 | ·741071              |
| 320  | ·142857              | 770  | ·343750              | 1220 | ·544643              | 1670 | ·745536              |
| 330  | ·147321              | 780  | ·348214              | 1230 | ·549107              | 1680 | ·750000              |
| 340  | ·151786              | 790  | ·352679              | 1240 | ·553571              | 1690 | ·754464              |
| 350  | ·156250              | 800  | ·357143              | 1250 | ·558036              | 1700 | ·758929              |
| 360  | ·160714              | 810  | ·361607              | 1260 | ·562500              | 1710 | ·763393              |

**TABLE OF THE DECIMAL EQUIVALENTS OF PARTS OF  
A TON (concluded).**

| Lbs. | Decimals<br>of a Ton | Lbs.              | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton |
|------|----------------------|-------------------|----------------------|------|----------------------|------|----------------------|
| 1720 | ·767857              | 1850              | ·825893              | 1980 | ·883929              | 2110 | ·941964              |
| 1730 | ·772321              | 1860              | ·830357              | 1990 | ·888393              | 2120 | ·946429              |
| 1740 | ·776786              | 1870              | ·834821              | 2000 | ·892857              | 2130 | ·950893              |
| 1750 | ·781250              | 1880              | ·839286              | 2010 | ·897321              | 2140 | ·955357              |
| 1760 | ·785714              | 1890              | ·843750              | 2020 | ·901786              | 2150 | ·959821              |
| 1770 | ·790179              | 1900              | ·848214              | 2030 | ·906250              | 2160 | ·964286              |
| 1780 | ·794643              | 1910              | ·852679              | 2040 | ·910714              | 2170 | ·968750              |
| 1790 | ·799107              | 1920              | ·857143              | 2050 | ·915179              | 2180 | ·973214              |
| 1800 | ·803571              | 1930              | ·861607              | 2060 | ·919643              | 2190 | ·977679              |
| 1810 | ·808036              | 1940              | ·866071              | 2070 | ·924107              | 2200 | ·982143              |
| 1820 | ·812500              | 1950              | ·870536              | 2080 | ·928571              | 2210 | ·986607              |
| 1830 | ·816964              | 1960              | ·875000              | 2090 | ·933036              | 2220 | ·991071              |
| 1840 | ·821429              | 1970              | ·879464              | 2100 | ·937500              | 2230 | ·995536              |
|      |                      | 2240 lbs. = 1 ton |                      |      |                      |      |                      |

| Ozs.           | Decimals<br>of a Lb. | Ozs.           | Decimals<br>of a Lb. | Ozs.            | Decimals<br>of a Lb. | Ozs.            | Decimals<br>of a Lb. |
|----------------|----------------------|----------------|----------------------|-----------------|----------------------|-----------------|----------------------|
| $\frac{1}{4}$  | ·015625              | $4\frac{1}{4}$ | ·265625              | $8\frac{1}{4}$  | ·515625              | $12\frac{1}{4}$ | ·765625              |
| $\frac{1}{2}$  | ·031250              | $4\frac{1}{2}$ | ·281250              | $8\frac{1}{2}$  | ·531250              | $12\frac{1}{2}$ | ·781250              |
| $\frac{3}{4}$  | ·046875              | $4\frac{3}{4}$ | ·296875              | $8\frac{3}{4}$  | ·546875              | $12\frac{3}{4}$ | ·796875              |
| 1              | ·062500              | 5              | ·312500              | 9               | ·562500              | 13              | ·812500              |
| $1\frac{1}{4}$ | ·078125              | $5\frac{1}{4}$ | ·328125              | $9\frac{1}{4}$  | ·578125              | $13\frac{1}{4}$ | ·828125              |
| $1\frac{1}{2}$ | ·093750              | $5\frac{1}{2}$ | ·343750              | $9\frac{1}{2}$  | ·593750              | $13\frac{1}{2}$ | ·843750              |
| $1\frac{3}{4}$ | ·109375              | $5\frac{3}{4}$ | ·359375              | $9\frac{3}{4}$  | ·609375              | $13\frac{3}{4}$ | ·859375              |
| 2              | ·125000              | 6              | ·375000              | 10              | ·625000              | 14              | ·875000              |
| $2\frac{1}{4}$ | ·140625              | $6\frac{1}{4}$ | ·390625              | $10\frac{1}{4}$ | ·640625              | $14\frac{1}{4}$ | ·890625              |
| $2\frac{1}{2}$ | ·156250              | $6\frac{1}{2}$ | ·406250              | $10\frac{1}{2}$ | ·656250              | $14\frac{1}{2}$ | ·906250              |
| $2\frac{3}{4}$ | ·171875              | $6\frac{3}{4}$ | ·421875              | $10\frac{3}{4}$ | ·671875              | $14\frac{3}{4}$ | ·921875              |
| 3              | ·187500              | 7              | ·437500              | 11              | ·687500              | 15              | ·937500              |
| $3\frac{1}{4}$ | ·203125              | $7\frac{1}{4}$ | ·453125              | $11\frac{1}{4}$ | ·703125              | $15\frac{1}{4}$ | ·953125              |
| $3\frac{1}{2}$ | ·218750              | $7\frac{1}{2}$ | ·468750              | $11\frac{1}{2}$ | ·718750              | $15\frac{1}{2}$ | ·968750              |
| $3\frac{3}{4}$ | ·234375              | $7\frac{3}{4}$ | ·484375              | $11\frac{3}{4}$ | ·734375              | $15\frac{3}{4}$ | ·984375              |
| 4              | ·250000              | 8              | ·500000              | 12              | ·750000              | 16              | 1·000000             |

| Qr. | Decimals<br>of a Ton | Qrs. | Decimals<br>of a Ton | Qrs. | Decimals<br>of a Ton | Qrs. | Decimals<br>of a Ton |
|-----|----------------------|------|----------------------|------|----------------------|------|----------------------|
| 1   | ·012500              | 2    | ·025000              | 3    | ·037500              | 4    | ·050000              |

| Cwts. | Decimals<br>of a Ton | Cwts. | Decimals<br>of a Ton | Cwts. | Decimals<br>of a Ton | Cwts. | Decimals<br>of a Ton | Cwts. | Decimals<br>of a Ton |
|-------|----------------------|-------|----------------------|-------|----------------------|-------|----------------------|-------|----------------------|
| 1     | ·050                 | 5     | ·250                 | 9     | ·450                 | 13    | ·650                 | 17    | ·850                 |
| 2     | ·100                 | 6     | ·300                 | 10    | ·500                 | 14    | ·700                 | 18    | ·900                 |
| 3     | ·150                 | 7     | ·350                 | 11    | ·550                 | 15    | ·750                 | 19    | ·950                 |
| 4     | ·200                 | 8     | ·400                 | 12    | ·600                 | 16    | ·800                 | 20    | 1·000                |

TABLE OF THE DECIMAL EQUIVALENTS OF THE DIVISIONS OF THE FOOT.

| In. | 0     | $\frac{1}{16}$ | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | In. |
|-----|-------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|-----|
| 0   | .0000 | .0052          | .0104         | .0156          | .0208         | .0260          | .0313         | .0365          | .0417         | .0469          | .0521         | .0573           | .0625         | .0677           | .0729         | .0781           | 0   |
| 1   | .0833 | .0885          | .0937         | .0990          | .1042         | .1094          | .1146         | .1198          | .1250         | .1302          | .1354         | .1406           | .1458         | .1510           | .1563         | .1615           | 1   |
| 2   | .1667 | .1719          | .1771         | .1823          | .1875         | .1927          | .1979         | .2031          | .2083         | .2135          | .2188         | .2240           | .2292         | .2344           | .2396         | .2448           | 2   |
| 3   | .2500 | .2552          | .2604         | .2656          | .2708         | .2760          | .2813         | .2865          | .2917         | .2969          | .3021         | .3073           | .3125         | .3177           | .3229         | .3281           | 3   |
| 4   | .3333 | .3385          | .3437         | .3490          | .3542         | .3594          | .3646         | .3698          | .3750         | .3802          | .3854         | .3906           | .3958         | .4010           | .4063         | .4115           | 4   |
| 5   | .4167 | .4219          | .4271         | .4323          | .4375         | .4427          | .4479         | .4531          | .4583         | .4635          | .4688         | .4740           | .4792         | .4844           | .4896         | .4948           | 5   |
| 6   | .5000 | .5052          | .5104         | .5156          | .5208         | .5260          | .5313         | .5365          | .5417         | .5469          | .5521         | .5573           | .5625         | .5677           | .5729         | .5781           | 6   |
| 7   | .5833 | .5885          | .5937         | .5990          | .6042         | .6094          | .6146         | .6198          | .6250         | .6302          | .6354         | .6406           | .6458         | .6510           | .6563         | .6615           | 7   |
| 8   | .6667 | .6719          | .6771         | .6823          | .6875         | .6927          | .6979         | .7031          | .7083         | .7135          | .7187         | .7240           | .7292         | .7344           | .7396         | .7448           | 8   |
| 9   | .7500 | .7552          | .7604         | .7656          | .7708         | .7760          | .7813         | .7865          | .7917         | .7969          | .8021         | .8073           | .8125         | .8177           | .8229         | .8281           | 9   |
| 10  | .8333 | .8385          | .8437         | .8490          | .8542         | .8594          | .8646         | .8698          | .8750         | .8802          | .8854         | .8906           | .8958         | .9010           | .9063         | .9115           | 10  |
| 11  | .9167 | .9219          | .9271         | .9323          | .9375         | .9427          | .9479         | .9531          | .9583         | .9635          | .9688         | .9740           | .9792         | .9844           | .9896         | .9948           | 11  |
| In. | 0     | $\frac{1}{16}$ | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | In. |

TABLE OF THE DECIMAL EQUIVALENTS OF THE DIVISIONS OF THE YARD.

| Feet | 0     | $\frac{1}{12}$ | $\frac{1}{6}$ | $\frac{1}{4}$ | $\frac{1}{3}$ | $\frac{5}{12}$ | $\frac{1}{2}$ | $\frac{7}{12}$ | $\frac{2}{3}$ | $\frac{9}{12}$ | $\frac{5}{6}$ | $\frac{11}{12}$ | Feet |
|------|-------|----------------|---------------|---------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|------|
| 0    | .0000 | .0278          | .0556         | .0833         | .1111         | .1389          | .1667         | .1944          | .2222         | .2500          | .2778         | .3056           | 0    |
| 1    | .3333 | .3611          | .3889         | .4167         | .4444         | .4722          | .5000         | .5278          | .5556         | .5833          | .6111         | .6389           | 1    |
| 2    | .6667 | .6944          | .7222         | .7500         | .7778         | .8056          | .8333         | .8611          | .8889         | .9167          | .9444         | .9722           | 2    |
| Feet | 0     | $\frac{1}{12}$ | $\frac{1}{6}$ | $\frac{1}{4}$ | $\frac{1}{3}$ | $\frac{5}{12}$ | $\frac{1}{2}$ | $\frac{7}{12}$ | $\frac{2}{3}$ | $\frac{9}{12}$ | $\frac{5}{6}$ | $\frac{11}{12}$ | Feet |

TABLE OF THE FRACTIONAL PARTS OF THE INCH, WITH THEIR CORRESPONDING DECIMALS.

| Decimals | Fractions       | Decimals | Fractions      | Decimals | Fractions      |
|----------|-----------------|----------|----------------|----------|----------------|
| 0078125  | $\frac{1}{128}$ | 3359375  | $\frac{1}{32}$ | 6718750  | $\frac{1}{32}$ |
| 0156250  | $\frac{1}{64}$  | 3437500  | $\frac{1}{32}$ | 6796875  | $\frac{1}{32}$ |
| 0234375  | $\frac{1}{32}$  | 3515625  | $\frac{1}{32}$ | 6875000  | $\frac{1}{32}$ |
| 0312500  | $\frac{1}{16}$  | 3593750  | $\frac{1}{32}$ | 6953125  | $\frac{1}{32}$ |
| 0390625  | $\frac{1}{16}$  | 3671875  | $\frac{1}{32}$ | 7031250  | $\frac{1}{32}$ |
| 0468750  | $\frac{1}{16}$  | 3750000  | $\frac{1}{32}$ | 7109375  | $\frac{1}{32}$ |
| 0546875  | $\frac{1}{16}$  | 3828125  | $\frac{1}{32}$ | 7187500  | $\frac{1}{32}$ |
| 0625000  | $\frac{1}{16}$  | 3906250  | $\frac{1}{32}$ | 7265625  | $\frac{1}{32}$ |
| 0703125  | $\frac{1}{16}$  | 3984375  | $\frac{1}{32}$ | 7343750  | $\frac{1}{32}$ |
| 0781250  | $\frac{1}{16}$  | 4062500  | $\frac{1}{32}$ | 7421875  | $\frac{1}{32}$ |
| 0859375  | $\frac{1}{16}$  | 4140625  | $\frac{1}{32}$ | 7500000  | $\frac{1}{32}$ |
| 0937500  | $\frac{1}{16}$  | 4218750  | $\frac{1}{32}$ | 7578125  | $\frac{1}{32}$ |
| 1015625  | $\frac{1}{16}$  | 4296875  | $\frac{1}{32}$ | 7656250  | $\frac{1}{32}$ |
| 1093750  | $\frac{1}{16}$  | 4375000  | $\frac{1}{32}$ | 7734375  | $\frac{1}{32}$ |
| 1171875  | $\frac{1}{16}$  | 4453125  | $\frac{1}{32}$ | 7812500  | $\frac{1}{32}$ |
| 1250000  | $\frac{1}{16}$  | 4531250  | $\frac{1}{32}$ | 7890625  | $\frac{1}{32}$ |
| 1328125  | $\frac{1}{16}$  | 4609375  | $\frac{1}{32}$ | 7968750  | $\frac{1}{32}$ |
| 1406250  | $\frac{1}{16}$  | 4687500  | $\frac{1}{32}$ | 8046875  | $\frac{1}{32}$ |
| 1484375  | $\frac{1}{16}$  | 4765625  | $\frac{1}{32}$ | 8125000  | $\frac{1}{32}$ |
| 1562500  | $\frac{1}{16}$  | 4843750  | $\frac{1}{32}$ | 8203125  | $\frac{1}{32}$ |
| 1640625  | $\frac{1}{16}$  | 4921875  | $\frac{1}{32}$ | 8281250  | $\frac{1}{32}$ |
| 1718750  | $\frac{1}{16}$  | 5000000  | $\frac{1}{32}$ | 8359375  | $\frac{1}{32}$ |
| 1796875  | $\frac{1}{16}$  | 5078125  | $\frac{1}{32}$ | 8437500  | $\frac{1}{32}$ |
| 1875000  | $\frac{1}{16}$  | 5156250  | $\frac{1}{32}$ | 8515625  | $\frac{1}{32}$ |
| 1953125  | $\frac{1}{16}$  | 5234375  | $\frac{1}{32}$ | 8593750  | $\frac{1}{32}$ |
| 2031250  | $\frac{1}{16}$  | 5312500  | $\frac{1}{32}$ | 8671875  | $\frac{1}{32}$ |
| 2109375  | $\frac{1}{16}$  | 5390625  | $\frac{1}{32}$ | 8750000  | $\frac{1}{32}$ |
| 2187500  | $\frac{1}{16}$  | 5468750  | $\frac{1}{32}$ | 8828125  | $\frac{1}{32}$ |
| 2265625  | $\frac{1}{16}$  | 5546875  | $\frac{1}{32}$ | 8906250  | $\frac{1}{32}$ |
| 2343750  | $\frac{1}{16}$  | 5625000  | $\frac{1}{32}$ | 8984375  | $\frac{1}{32}$ |
| 2421875  | $\frac{1}{16}$  | 5703125  | $\frac{1}{32}$ | 9062500  | $\frac{1}{32}$ |
| 2500000  | $\frac{1}{16}$  | 5781250  | $\frac{1}{32}$ | 9140625  | $\frac{1}{32}$ |
| 2578125  | $\frac{1}{16}$  | 5859375  | $\frac{1}{32}$ | 9218750  | $\frac{1}{32}$ |
| 2656250  | $\frac{1}{16}$  | 5937500  | $\frac{1}{32}$ | 9296875  | $\frac{1}{32}$ |
| 2734375  | $\frac{1}{16}$  | 6015625  | $\frac{1}{32}$ | 9375000  | $\frac{1}{32}$ |
| 2812500  | $\frac{1}{16}$  | 6093750  | $\frac{1}{32}$ | 9453125  | $\frac{1}{32}$ |
| 2890625  | $\frac{1}{16}$  | 6171875  | $\frac{1}{32}$ | 9531250  | $\frac{1}{32}$ |
| 2968750  | $\frac{1}{16}$  | 6250000  | $\frac{1}{32}$ | 9609375  | $\frac{1}{32}$ |
| 3046875  | $\frac{1}{16}$  | 6328125  | $\frac{1}{32}$ | 9687500  | $\frac{1}{32}$ |
| 3125000  | $\frac{1}{16}$  | 6406250  | $\frac{1}{32}$ | 9765625  | $\frac{1}{32}$ |
| 3203125  | $\frac{1}{16}$  | 6484375  | $\frac{1}{32}$ | 9843750  | $\frac{1}{32}$ |
| 3281250  | $\frac{1}{16}$  | 6562500  | $\frac{1}{32}$ | 9921875  | $\frac{1}{32}$ |
|          |                 | 6640625  | $\frac{1}{32}$ | 10000000 | $\frac{1}{32}$ |

TABLE OF FOREIGN MONEY, WEIGHTS, AND MEASURES,  
WITH THEIR ENGLISH VALUE.

| Countries           | MONEY              |                  |                   |                  |              |             |
|---------------------|--------------------|------------------|-------------------|------------------|--------------|-------------|
|                     | Gold Coins         | Value            | Silver Coins      | Value            | Silver Coins | Value       |
| Austria             | 8 florins          | £ s. d.<br>15 10 | 2 florins         | £ s. d.<br>8 11½ | ½ florin     | s. d.<br>5½ |
| Bombay              | Mohur              | 1 10 1½          | Cos. rupee        | 1 9 2½           | ½ rupee      | 5½          |
| China               | —                  | —                | Tael              | 6 8              | Mace         | 8           |
| Denmark             | 20 kron-daler      | 1 1 11½          | 4 kron-daler      | 4 5½             | Kron-daler   | 1 1½        |
| France <sup>1</sup> | 20 francs          | 15 10            | 5 francs          | 3 10             | Frano        | 9½          |
| Germany             | 20 reichs-<br>mark | 1 0 0            | 5 reichs-<br>mark | 5 0              | 20 pfennige  | 2½          |
| Greece              | 20 drachma         | 14 2½            | 5 drachma         | 3 7½             | Drachma      | 8½          |
| Holland             | Ryder              | 1 4 9½           | Guilder           | 1 8              | 25 cents     | 5           |
| Madras              | Rupæe              | 1 9 2½           | Cos. rupee        | 1 10½            | ½ rupee      | 5½          |
| Portugal            | 5 milreas          | 1 2 2½           | 500 reas          | 2 2½             | 50 reas      | 2½          |
| Russia              | 10 roubles         | 1 12 2½          | Rouble            | 3 2              | 25 copecs    | 9½          |
| Spain               | 20 pesetas         | 15 10            | 5 pesetas         | 3 11½            | Peseta       | 9½          |
| Sweden              | 20 kron-daler      | 1 1 11½          | 4 krou-daler      | 4 5½             | Daler        | 8½          |

| Countries | LENGTH     |                  |           |                |            |                 |
|-----------|------------|------------------|-----------|----------------|------------|-----------------|
|           | Measure    | Length           | Measure   | Length         | Measure    | Length          |
| Austria   | Fuss       | Inches<br>12·445 | Klafter   | Feet<br>6·2226 | Meile      | Miles<br>4·7142 |
| Bombay    | Hath       | 18               | Guz       | 2·25           | —          | —               |
| China     | Chik       | 14·1             | Yan       | 117·5          | Li         | ·8458           |
| Denmark   | Fod        | 12·357           | Aln       | 2·0595         | Mil        | 4·6807          |
| France    | Mètre      | 89·3704          | Décimètre | 32·809         | Myriamètre | 6·2138          |
| Germany   | Fuss       | 12·357           | Ruthe     | 12·357         | Postmeile  | 4·6807          |
| Greece    | Attic foot | 12·10            | Stadium   | 600            | —          | —               |
| Holland   | Palm       | 3·93704          | Elle      | 3·2809         | Mijle      | ·6214           |
| Madras    | Covid      | 18·6             | —         | —              | —          | —               |
| Portugal  | Palmo      | 8·656            | Vara      | 3·6067         | Mil        | 1·2786          |
| Russia    | Archine    | 28               | Sachine   | 7              | Verst      | ·6629           |
| Spain     | Pie        | 11·128           | Vara      | 2·782          | Legua      | 4·2152          |
| Sweden    | Fot        | 11·6904          | Famn      | 5·8452         | Mil        | 6·4422          |

| Countries | LIQUID CAPACITY |         |           |         |            |         |
|-----------|-----------------|---------|-----------|---------|------------|---------|
|           | Measures        | Gallons | Measures  | Gallons | Measures   | Gallons |
| Austria   | Kanne           | ·1557   | Viertel   | 3·1143  | Eimer      | 12·4572 |
| Bombay    | Adoulie         | 1·515   | Para      | 24·24   | Candy      | 193·92  |
| China     | Shingtsong      | ·12     | Tau       | 1·2     | Hwäh       | 12      |
| Denmark   | Pott            | ·2126   | Viertel   | 1·7008  | Anker      | 8·2914  |
| France    | Litre           | ·2201   | Décalitre | 2·2009  | Hectolitre | 22·0097 |
| Germany   | Quartier        | ·252    | Anker     | 7·559   | Eimer      | 15·118  |
| Greece    | —               | —       | Metretes  | 8·488   | —          | —       |
| Holland   | Kan             | ·2201   | —         | —       | Vat        | 22·0097 |
| Madras    | Puddy           | ·338    | Marcal    | 2·704   | Parah      | 13·52   |
| Portugal  | Canada          | ·8034   | Pote      | 1·8202  | Almüde     | 3·6405  |
| Russia    | Vedro           | 2·7049  | Anker     | 3·1147  | Sarokowaja | 824·588 |
| Spain     | Quartillo       | ·1105   | Azumbre   | ·4422   | Arroba     | 3·5380  |
| Sweden    | Stop            | ·2876   | Kanna     | ·5756   | Tunna      | 27·6288 |

<sup>1</sup> France, Italy, Belgium, and Switzerland have perfect reciprocity in their currency.





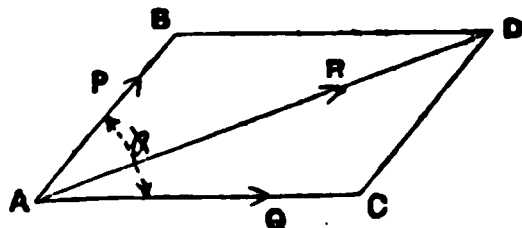
## MECHANICAL PRINCIPLES.

## RESULTANT AND RESOLUTION OF FORCES.

1. *To find the resultant of two forces acting through one point but not in the same direction.* (Fig. 118.)

Let AB, AC represent the two forces P and Q acting through the point A; complete the parallelogram ABCD: then its diagonal AD will represent in magnitude and direction the resultant of the two forces P and Q.

FIG. 118.



R = resultant.

$\theta$  = angle P makes with Q.

$\alpha$  = angle R makes with Q.  $\beta$  = angle R makes with P.

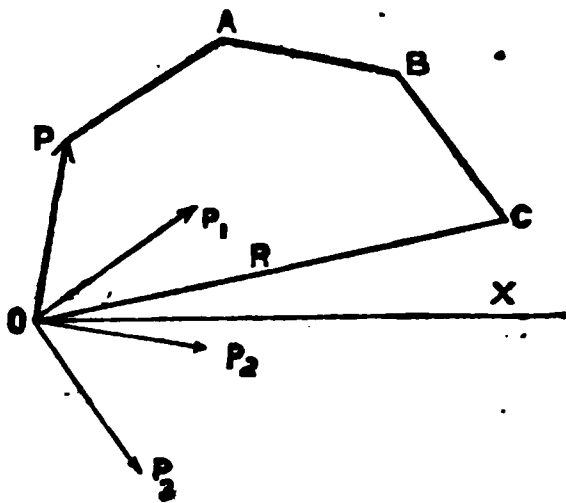
$$R = \sqrt{P^2 + Q^2 + 2PQ \cdot \cos \theta};$$

$$\sin \alpha = \sin \theta \frac{P}{R}; \quad \sin \beta = \sin \theta \frac{Q}{R}.$$

2. *To find the resultant of any number of forces acting in the same plane and through one point but not in the same direction.* (Fig. 119.)

Let P, P<sub>1</sub>, P<sub>2</sub>, P<sub>3</sub> be the forces acting through the point of application O; commence at O and construct a chain of lines OP, PA, AB, BC, representing the forces in magnitude and parallel to them; let C be the end of the chain: then a line R joining OC will represent in magnitude and direction the resultant of the forces P, P<sub>1</sub>, P<sub>2</sub>, and P<sub>3</sub>.

FIG. 119.



*Note.*—This geometrical problem is true whether the forces act in the same or in different planes.

R = resultant.

$\theta$  = angle made by R with a fixed axis CX.

$a, a_1, a_2, \&c.$  = angles made by the forces P, P<sub>1</sub>, P<sub>2</sub>, &c., with OX.

$\Sigma X$  = sum of the series of  $P \cdot \cos a + P_1 \cdot \cos a_1 + P_2 \cdot \cos a_2, \&c.$

$\Sigma Y$  = sum of the series of  $P \cdot \sin a + P_1 \cdot \sin a_1 + P_2 \cdot \sin a_2, \&c.$

$$R \cdot \cos \theta = \Sigma X. \quad R = \sqrt{(\Sigma X)^2 + (\Sigma Y)^2}$$

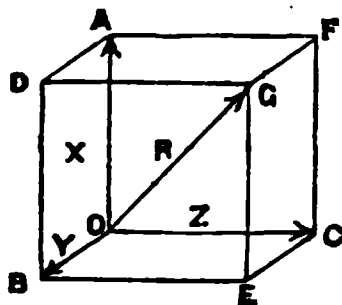
$$R \cdot \sin \theta = \Sigma Y. \quad \tan \theta = \frac{\Sigma Y}{\Sigma X}$$

$$\cos \theta = \frac{\Sigma X}{R}$$

$$\sin \theta = \frac{\Sigma Y}{R}$$

3. To find the resultant of three forces acting through one point and making right angles with one another. (Fig. 120.)

FIG. 120.



Let OA, OB, OC represent in magnitude and direction the forces X, Y, Z acting through one point O; complete the rectangular solid AEFB: then its diagonal OG will represent in magnitude and direction the resultant of the forces X, Y, Z.

R = resultant.

$\alpha, \beta, \gamma$  = the angles R makes with X, Y, Z, respectively.

$$Y = R \cdot \cos \beta. \quad R = \sqrt{X^2 + Y^2 + Z^2}.$$

$$Z = R \cdot \cos \gamma. \quad X = R \cdot \cos \alpha.$$

4. To find the resultant of any number of forces acting through one point in different directions and not in the same plane.

Let P, P<sub>1</sub>, P<sub>2</sub>, &c., be the forces  $\alpha, \beta, \gamma; \alpha_1, \beta_1, \gamma_1; \alpha_2, \beta_2, \gamma_2$ , the angles their direction makes with three axes passing through the point of application and making right angles with one another.

R = resultant.

$$\Sigma X = P \cdot \cos \alpha + P_1 \cdot \cos \alpha_1 + P_2 \cdot \cos \alpha_2 + \&c.$$

$$\Sigma Y = P \cdot \cos \beta + P_1 \cdot \cos \beta_1 + P_2 \cdot \cos \beta_2 + \&c.$$

$$\Sigma Z = P \cdot \cos \gamma + P_1 \cdot \cos \gamma_1 + P_2 \cdot \cos \gamma_2 + \&c.$$

$$R = \sqrt{(\Sigma X)^2 + (\Sigma Y)^2 + (\Sigma Z)^2}$$

$$\cos \alpha = \frac{\Sigma X}{R}$$

$$\cos \beta = \frac{\Sigma Y}{R}$$

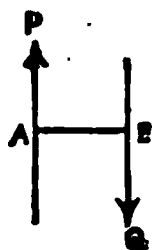
$$\cos \gamma = \frac{\Sigma Z}{R}.$$

N.B. Cosines of obtuse angles are negative.

### PARALLEL FORCES.

A couple consists of two equal forces, as P and Q (see fig. 121), acting in parallel and opposite directions to one another, and is termed a right- or left-handed couple, according to whether the forces tend to turn the rigid body in a right- or left-handed direction.

FIG. 121.



The moment of a couple is the product of either of the forces into the perpendicular distance AB between the lines of direction of the forces. The distance AB is termed the arm or lever of the couple.

5. To find the resultant moment of any number of couples acting upon a body in the same or parallel planes.

RULE.—Add together the moments of the right- and left-

handed couples separately; the difference between the two sums will be the resultant moment, which will be right- or left-handed, according to which sum is the greater.

6. *To find the resultant of two parallel forces.* (Figs. 122 and 123.)

The magnitude of the resultant of two parallel forces is their sum or difference, according to whether they act in the same or contrary directions.

Let fig. 122 represent a case in which the two forces act in the same direction, and fig. 123 a case in which the components act in opposite directions.

Let AB and CD represent the two forces; join AD and CB, cutting each other in E; in DA (produced in fig. 123) take DF = BA; through F draw a line parallel to the components; this will be the line of the resultant, and if two lines DG and AH be drawn parallel to BC, cutting the line of action of the resultant in G and H, GH will represent the magnitude of the resultant.

FIG. 122.

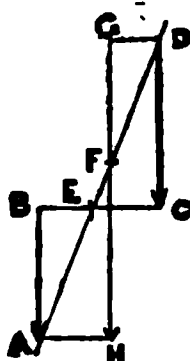
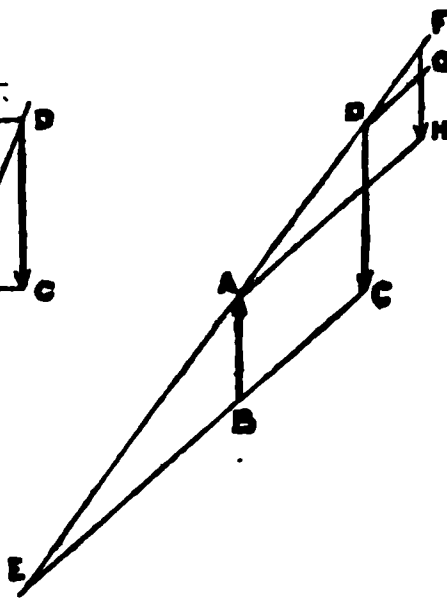


FIG. 123.



$$AF = \frac{DC \cdot AD}{GH}.$$

$$DF = \frac{AB \cdot AD}{GH}.$$

7. *To find the resultant of any number of parallel forces.*

**RULE.**—Take the sum of all those forces which act in *one* direction, and distinguish them as positive; then take the sum of all the other forces which act in the *contrary* direction, and distinguish them as negative. The direction of the resultant (positive or negative) will be in that of the greater of these two sums, and its magnitude will be the difference between them.

8. *To find the position of the resultant of any number of parallel forces when they act in two contrary directions.*

**RULE.**—1st. Multiply each force by its perpendicular distance from an assumed axis in a plane perpendicular to the lines of action of the forces; distinguish those moments into right- and left-handed, and take their resultant, which divide by the resultant force: the quotient will be the perpendicular distance of that force from the assumed axis.

2nd. Find by a similar process the perpendicular distance of the resultant force from another axis perpendicular to the first and in the same plane.

TABLE GIVING THE EQUIVALENTS OF KILOGRAMS IN AVOIRDUPOIS POUNDS AND TONS (concluded).

| Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       | Kilos. | Avoir. Lbs. | Ton       |
|--------|-------------|-----------|--------|-------------|-----------|--------|-------------|-----------|--------|-------------|-----------|
| 101    | 222.66675   | .09940480 | 126    | 277.78228   | .12400995 | 151    | 332.89781   | .14861509 | 176    | 388.01334   | .17322024 |
| 102    | 224.87137   | .10038900 | 127    | 279.98690   | .12499415 | 152    | 335.10243   | .14959930 | 177    | 390.21796   | .17420445 |
| 103    | 227.07599   | .10137321 | 128    | 282.29152   | .12597836 | 153    | 337.30705   | .15058351 | 178    | 392.42258   | .17518865 |
| 104    | 229.28061   | .10235742 | 129    | 284.49614   | .12696256 | 154    | 339.51167   | .15156771 | 179    | 394.62720   | .17617286 |
| 105    | 231.48523   | .10334162 | 130    | 286.60076   | .12794677 | 155    | 341.71629   | .15255192 | 180    | 396.83183   | .17715706 |
| 106    | 233.68985   | .10432583 | 131    | 288.80538   | .12893097 | 156    | 343.92092   | .15353612 | 181    | 399.03645   | .17814127 |
| 107    | 235.89447   | .10531003 | 132    | 291.01001   | .12991518 | 157    | 346.12554   | .15452033 | 182    | 401.24107   | .17912548 |
| 108    | 238.09910   | .10629424 | 133    | 293.21463   | .13089939 | 158    | 348.33016   | .15550453 | 183    | 403.44569   | .18010968 |
| 109    | 240.30372   | .10727844 | 134    | 295.41925   | .13188359 | 159    | 350.53478   | .15648874 | 184    | 405.65031   | .18109389 |
| 110    | 242.50834   | .10826265 | 135    | 297.62387   | .13286780 | 160    | 352.73940   | .15747295 | 185    | 407.85493   | .18207809 |
| 111    | 244.71296   | .10924686 | 136    | 299.82849   | .13385200 | 161    | 354.94402   | .15845715 | 186    | 410.05955   | .18306230 |
| 112    | 246.91758   | .11023106 | 137    | 302.03311   | .13483621 | 162    | 357.14864   | .15944136 | 187    | 412.26417   | .18404651 |
| 113    | 249.12220   | .11121527 | 138    | 304.23773   | .13582042 | 163    | 359.35326   | .16042556 | 188    | 414.46880   | .18503071 |
| 114    | 251.32682   | .11219947 | 139    | 306.44235   | .13680462 | 164    | 361.55789   | .16140977 | 189    | 416.67342   | .18601492 |
| 115    | 253.53144   | .11318368 | 140    | 308.64698   | .13778883 | 165    | 363.76251   | .16239398 | 190    | 418.87804   | .18699912 |
| 116    | 255.73607   | .11416789 | 141    | 310.85160   | .13877303 | 166    | 365.96713   | .16337818 | 191    | 421.08266   | .18798333 |
| 117    | 257.94069   | .11515209 | 142    | 313.05622   | .13975724 | 167    | 368.17175   | .16436239 | 192    | 423.28728   | .18896754 |
| 118    | 260.14531   | .11613630 | 143    | 315.26084   | .14074145 | 168    | 370.37637   | .16534659 | 193    | 425.49190   | .18995174 |
| 119    | 262.34993   | .11712050 | 144    | 317.46546   | .14172565 | 169    | 372.58099   | .16633080 | 194    | 427.69652   | .19093595 |
| 120    | 264.55455   | .11810471 | 145    | 319.67008   | .14270986 | 170    | 374.78561   | .16731501 | 195    | 429.90114   | .19192015 |
| 121    | 266.75917   | .11908892 | 146    | 321.87470   | .14369406 | 171    | 376.99023   | .16829921 | 196    | 432.10577   | .19290436 |
| 122    | 268.96379   | .12007312 | 147    | 324.07932   | .14467827 | 172    | 379.19486   | .16928342 | 197    | 434.31039   | .19388857 |
| 123    | 271.16841   | .12105733 | 148    | 326.28395   | .14566248 | 173    | 381.39948   | .17026762 | 198    | 436.51501   | .19487277 |
| 124    | 273.37304   | .12204153 | 149    | 328.48857   | .14664668 | 174    | 383.60410   | .17125183 | 199    | 438.71963   | .19585698 |
| 125    | 275.57766   | .12302574 | 150    | 330.69319   | .14763089 | 175    | 385.80872   | .17223604 | 200    | 440.92425   | .19684118 |

TABLE OF THE DECIMAL EQUIVALENTS OF PARTS OF A TON.

| Lbs. | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton | Lbs. | Decimals<br>of a Ton |
|------|----------------------|------|----------------------|------|----------------------|------|----------------------|
| 1    | ·000446              | 370  | ·165179              | 820  | ·366071              | 1270 | ·566964              |
| 2    | ·000893              | 380  | ·169643              | 830  | ·370536              | 1280 | ·571429              |
| 3    | ·001339              | 390  | ·174107              | 840  | ·375000              | 1290 | ·575893              |
| 4    | ·001786              | 400  | ·178571              | 850  | ·379464              | 1300 | ·580357              |
| 5    | ·002232              | 410  | ·183036              | 860  | ·383929              | 1310 | ·584821              |
| 6    | ·002679              | 420  | ·187500              | 870  | ·388393              | 1320 | ·589286              |
| 7    | ·003125              | 430  | ·191964              | 880  | ·392857              | 1330 | ·593750              |
| 8    | ·003571              | 440  | ·196429              | 890  | ·397321              | 1340 | ·598214              |
| 9    | ·004018              | 450  | ·200893              | 900  | ·401786              | 1350 | ·602679              |
| 10   | ·004464              | 460  | ·205357              | 910  | ·406250              | 1360 | ·607143              |
| 20   | ·008929              | 470  | ·209821              | 920  | ·410714              | 1370 | ·611607              |
| 30   | ·013393              | 480  | ·214286              | 930  | ·415179              | 1380 | ·616071              |
| 40   | ·017857              | 490  | ·218750              | 940  | ·419643              | 1390 | ·620536              |
| 50   | ·022321              | 500  | ·223214              | 950  | ·424107              | 1400 | ·625000              |
| 60   | ·026786              | 510  | ·227679              | 960  | ·428571              | 1410 | ·629464              |
| 70   | ·031250              | 520  | ·232143              | 970  | ·433036              | 1420 | ·633929              |
| 80   | ·035714              | 530  | ·236607              | 980  | ·437500              | 1430 | ·638393              |
| 90   | ·040179              | 540  | ·241071              | 990  | ·441964              | 1440 | ·642857              |
| 100  | ·044643              | 550  | ·245536              | 1000 | ·446429              | 1450 | ·647321              |
| 110  | ·049107              | 560  | ·250000              | 1010 | ·450893              | 1460 | ·651786              |
| 120  | ·053571              | 570  | ·254464              | 1020 | ·455357              | 1470 | ·656250              |
| 130  | ·058036              | 580  | ·258929              | 1030 | ·459821              | 1480 | ·660714              |
| 140  | ·062500              | 590  | ·263393              | 1040 | ·464286              | 1490 | ·665179              |
| 150  | ·066964              | 600  | ·267857              | 1050 | ·468750              | 1500 | ·669643              |
| 160  | ·071429              | 610  | ·272321              | 1060 | ·473214              | 1510 | ·674107              |
| 170  | ·075893              | 620  | ·276786              | 1070 | ·477679              | 1520 | ·678571              |
| 180  | ·080357              | 630  | ·281250              | 1080 | ·482143              | 1530 | ·683036              |
| 190  | ·084821              | 640  | ·285714              | 1090 | ·486607              | 1540 | ·687500              |
| 200  | ·089286              | 650  | ·290179              | 1100 | ·491071              | 1550 | ·691964              |
| 210  | ·093750              | 660  | ·294643              | 1110 | ·495536              | 1560 | ·696429              |
| 220  | ·098214              | 670  | ·299107              | 1120 | ·500000              | 1570 | ·700893              |
| 230  | ·102679              | 680  | ·303571              | 1130 | ·504464              | 1580 | ·705357              |
| 240  | ·107143              | 690  | ·308036              | 1140 | ·508929              | 1590 | ·709821              |
| 250  | ·111607              | 700  | ·312500              | 1150 | ·513393              | 1600 | ·714286              |
| 260  | ·116071              | 710  | ·316964              | 1160 | ·517857              | 1610 | ·718750              |
| 270  | ·120536              | 720  | ·321429              | 1170 | ·522321              | 1620 | ·723214              |
| 280  | ·125000              | 730  | ·325893              | 1180 | ·526786              | 1630 | ·727679              |
| 290  | ·129464              | 740  | ·330357              | 1190 | ·531250              | 1640 | ·732143              |
| 300  | ·133929              | 750  | ·334821              | 1200 | ·535714              | 1650 | ·736607              |
| 310  | ·138393              | 760  | ·339286              | 1210 | ·540179              | 1660 | ·741071              |
| 320  | ·142857              | 770  | ·343750              | 1220 | ·544643              | 1670 | ·745536              |
| 330  | ·147321              | 780  | ·348214              | 1230 | ·549107              | 1680 | ·750000              |
| 340  | ·151786              | 790  | ·352679              | 1240 | ·553571              | 1690 | ·754464              |
| 350  | ·156250              | 800  | ·357143              | 1250 | ·558036              | 1700 | ·758929              |
| 360  | ·160714              | 810  | ·361607              | 1260 | ·562500              | 1710 | ·763393              |

## VELOCITY OF FALLING BODIES.

$h$  = height or depth of fall in feet.

$t$  = time of fall in seconds.

$v$  = velocity acquired at end of time  $t$ .

$g$  = accelerating force of gravity = 32.2 nearly.

$$v = gt = \frac{2h}{t} = \sqrt{2gh}; \quad h = \frac{vt}{2} = \frac{gt^2}{2} = \frac{v^2}{2g}; \quad t = \frac{\sqrt{2h}}{g}.$$

The velocity acquired by a body falling down an incline is equal to that which it would acquire in falling down its perpendicular altitude (see fig. 124).

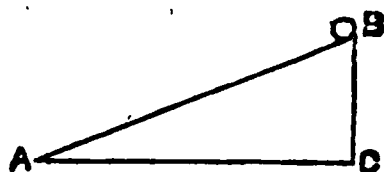
$t$  = time falling from B to A in seconds.

FIG. 124.

$l$  = length of incline BA in feet.

$h$  = altitude of incline BC in feet.

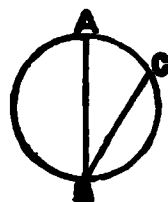
$g$  = accelerating force of gravity = 32.2 nearly.



$$t = \frac{\sqrt{2l^2}}{gh}.$$

FIG. 125.

If a chord BC be drawn from either extremity of a vertical diameter AB of a circle, the time of descent of a body falling down the chord BC will equal the time of descent down the diameter AB (see fig. 125).



## ROTATION ACCELERATED AND RETARDED.

*Accelerated.*

$W$  = weight of body in lbs.

$M$  = moment of accelerating force in foot lbs.

$E$  = energy exerted.

$v$  = original angular velocity.

$v'$  = increased angular velocity.

$\theta$  = the circular motion during the action of the force in circular measure.

$n$  = original speed of circular motion in turns per second.

$n'$  = increased speed of circular motion in turns per second.

$r$  = length of arm at the end of which  $W$  revolves in feet.

$t$  = time during which  $M$  acts in seconds.

$g$  = force of gravity = 32.2 nearly.

$$Mt = \frac{Wr^2(v' - v)}{g} = \frac{2\pi Wr^2(n' - n)}{g}.$$

$$E = M\theta = Mt \frac{v' + v}{2} = \frac{Wr^2(v'^2 - v^2)}{2g} = \frac{4\pi^2 Wr^2(n'^2 - n^2)}{2g}.$$

*Retarded.*

Use the same notation as for acceleration, but substituting moment of *retarding force* for moment of *accelerating force*, *diminution* for *increase* of velocity and its square, and *work performed* for *energy*.

**MOMENT OF INERTIA OF WEIGHT AND RADIUS OF GYRATION.**

(See also pp. 78–81.)

$m, m', m'', \&c.$  = weight of indefinitely small particles composing the body.

$d, d', d'', \&c.$  = respective distances of  $m, m', m'', \&c.$ , from a fixed axis.

$W$  = weight of whole body =  $m + m' + m'' + \&c.$

$I$  = moment of inertia of  $W$  about a fixed axis.

$R$  = radius of gyration.

$$R = \sqrt{\frac{I}{W}}. \quad I = md^2 + m'd'^2 + m''d''^2 + \&c.^2$$

**IMPULSE ON A FREE SOLID BODY.**

A *single impulse* acting on a body through its centre of gravity impresses a motion of translation in the direction of the impulse.

$v$  = velocity of translation.

$F$  = force applied.

$t$  = time during which  $F$  acts.

$g$  = accelerating force of gravity = 32.2 nearly.

$w$  = weight of body.

$$v = \frac{Fgt}{w}, \quad F = \frac{gt}{v w}.$$

The *impulse of a couple* impresses on a body a motion of rotation about its centre of gravity.

$A$  = angular velocity in circular measure.

$L$  = linear velocity produced by one of two impulses.

$F$  = force applied.

$W$  = weight of body.

$M$  = moment of inertia of  $W$ .

$R^2$  = square of radius of gyration.

$l$  = length of arm of couple.

$m$  = moment of couple.

$t$  = time during which  $F$  acts.

$g$  = accelerating force of gravity = 32.2 nearly.

$$A = \frac{mtg}{M} = \frac{Fltg}{WR^2} = \frac{Lt}{R^2}.$$





### DEVIATING AND CENTRIFUGAL FORCE.

**D** = deviating force of body revolving in a circle at a uniform speed.

**W** = weight of body.

**N** = number of revolutions per minute.

**n** = number of revolutions per second.

**l** = linear velocity in feet per second.

**a** = angular velocity in circular measure per second.

**r** = radius of circle in feet.

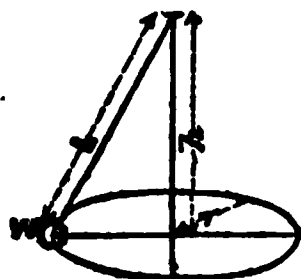
**g** = accelerating force of gravity = 32.2 nearly.

$$D = \frac{Wl^2}{gr} = \frac{Wra^2}{g} = \frac{4Wn\pi r}{g} = \frac{Wn^2r}{.8154} = \frac{WN^2r}{.2935}.$$

*Centrifugal force* is exactly equal and opposite to the deviating force.

### REVOLVING PENDULUM (Fig. 127).

FIG. 127.



**D** = deviating force.

**W** = weight of bob.

**N** = number of revolutions per minute.

**n** = number of revolutions per second.

**h** = height of pendulum in feet.

**r** = radius of circle in feet.

**g** = accelerating force of gravity = 32.2 nearly.

$$h = \frac{Wr}{D} = \frac{g}{4\pi^2n^2} = \frac{.8154}{n^2} = \frac{.2935}{N^2}$$

$$n = \sqrt{\frac{.8154}{h}}$$

$$N = \sqrt{\frac{.2935}{h}}$$

### COMPUTATION OF A SHIP'S DISPLACEMENT.

This consists in computing the volume of the body of the vessel below the water-plane, up to which it is required to know her displacement, by one of the rules used for finding the volume of solids bounded on one side by a curved surface (see pp. 44, 45).

Two processes are generally made use of in computing a vessel's displacement, as the calculations in each process are required to determine the position of the centre of gravity of displacement, or centre of buoyancy, and also because the two results are a check on the correctness of the calculations.

One process consists in dividing the length of the ship on the load water-line by a number of equidistant vertical sections, computing their several areas by one of Simpson's rules, and then treating them as if they were the ordinates of a new curve, the base of which is the load water-line.

The other process consists in dividing the depth of the vessel below the load water-line by a number of equidistant longitudinal planes parallel to the load water-line; the areas of their several planes are then computed by one of Simpson's rules, and those areas are treated as if they were the ordinates of a new curve, the base of which is the vertical distance between the load water-line and first lowest longitudinal plane.

As the vessel generally consists of two symmetrical halves, the volume of only half the vessel, below the load water-line, is calculated, the ordinates all being measured from a longitudinal vertical plane at the middle of the ship.

For example of displacement papers see pp. 155 and 156.

#### DETERMINATION OF A SHIP'S CENTRE OF BUOYANCY FOR THE UPRIGHT POSITION.

The centre of buoyancy is also termed the centre of gravity of displacement, as it occupies the same point as the centre of gravity of the volume of water displaced by the vessel, and its position is determined by the rules used for finding the centre of gravity of solids, bounded on one side by a curved surface (see rules, pp. 78 and 79), with the exception that its position need only be determined for its vertical distance from a horizontal plane, and its horizontal distance from a vertical plane; for the ship consisting of two symmetrical halves, it must necessarily lay in the longitudinal vertical plane in the middle of the ship.

Calculation of the centre of buoyancy is generally performed on the displacement paper (see pp. 155 and 156).

#### VERTICAL HEIGHT OF TRANSVERSE METACENTRE ABOVE CENTRE OF BUOYANCY FOR UPRIGHT POSITION.

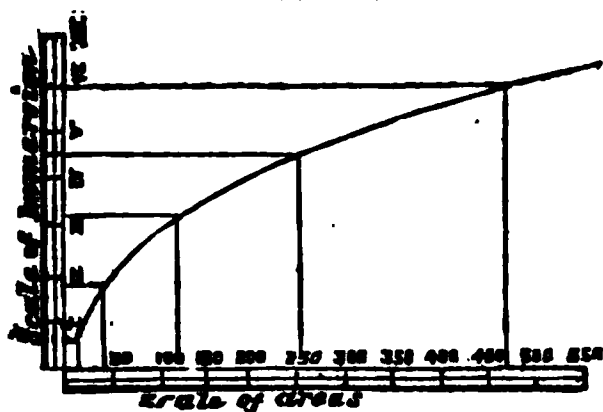
The transverse metacentre of vessel for all angles of heel always lies in a longitudinal vertical plane bisecting the ship, and vertically over its corresponding centre of buoyancy; its vertical height above the centre of buoyancy for its upright position is found by dividing the moment of inertia of the load water-plane relatively to the middle line of the vessel by the volume of displacement (see pp. 164 and 165). This calculation is also generally performed upon the displacement paper (see p. 155).

#### CURVE OF AREAS OF MIDSHIP SECTION.

This curve (see fig. 128) is used to determine the area of the immersed part of the midship section of a vessel at any given draught of water.

*Method of Construction.*—Compute the areas of the midship section from the keel up to the several longitudinal water-planes

FIG. 128.

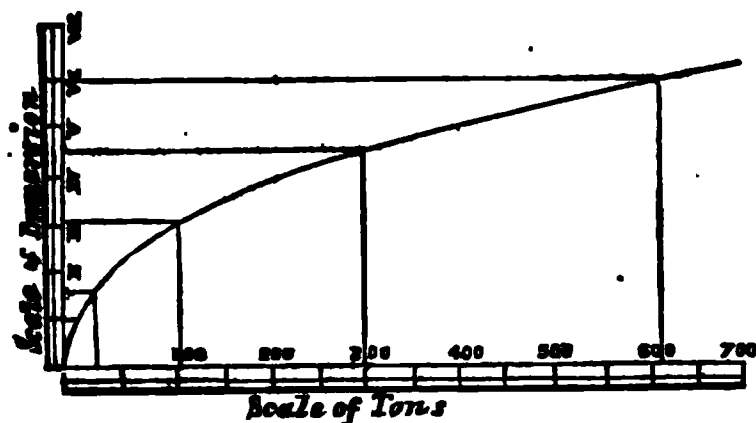


which are used for calculating the displacement; set these areas off along a base line as ordinates, in their consecutive order, the abscissæ of which represent to scale the respective distances between the longitudinal water-planes: a curve bent through the extremities of these ordinates will form the required curve.

### CURVE OF DISPLACEMENT.

This curve is used to determine the displacement a vessel has at any draught of water parallel to the load water-line (see fig. 129).

FIG. 129.

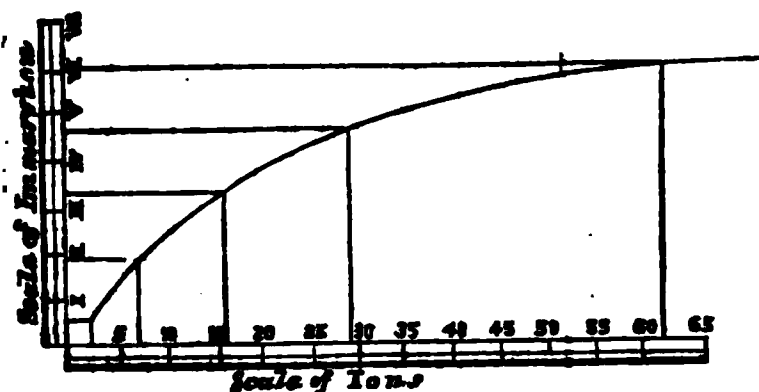


*Method of Construction.*—This curve is constructed in a similar manner to the foregoing curve, with the exception that the ordinates represent the several volumes of displacement (in tons of 35 cubic feet for salt water, and 36 cubic

feet for fresh water) up to their respective longitudinal water-planes.

### CURVE OF TONS PER INCH OF IMMERSION.

FIG. 130.



This curve (see fig. 130) is used to determine the number of tons required to immerse a vessel one inch at any draught of water parallel to the load water-plane.

To find the displacement per inch in cubic feet at any

water-plane, divide the area of that plane by 12; and if the displacement per inch is required in tons, divide by 35 or 36, as the case may be.

A = area of longitudinal water-plane in square feet.

T = tons per inch of immersion at that water-plane.

$$T = \frac{A}{12 \times 35} \text{ for salt water; } T = \frac{A}{12 \times 36} \text{ for fresh water.}$$

*Method of Construction.*—This curve is also constructed in a similar manner to the two foregoing curves, with the exception that the ordinates represent to scale the tons per inch of immersion at the respective water-planes.

## COEFFICIENTS OF FINENESS.

*The coefficient of fineness of displacement of a vessel is the ratio that the volume of the displacement bears to the parallelepipedon circumscribing the immersed body.*

- V = volume of displacement in cubic feet.  
 L = length of vessel at load water-line in feet.  
 B = extreme immersed breadth in feet.  
 D = draught of water in feet.  
 K = coefficient of fineness.

$$K = \frac{V}{L \times B \times D}.$$

*The coefficient of fineness of a midship section, or of a water-plane, is the ratio which their respective areas bear to that of their circumscribing rectangle.*

*To determine the mean coefficient of all the water-planes of a ship.*

**RULE.**—Multiply the immersed area of the midship section by the length of the load water-line, and divide the volume of displacement by the product.

TABLE OF COEFFICIENTS OF FINENESS.

| Class of Ship                                    | Length     | Breadth    | Mean Draught | Coeff. of Displ. | Coeff. of Mid. Sect. | Coeff. of Water-Plane |
|--|------------|------------|--------------|------------------|----------------------|-----------------------|
| Fast steamer, H.M. Royal Yacht                   | Feet 300.0 | Feet 40.27 | Feet 14.0    | .414             | .711                 | .711                  |
| Swift steam cruisers { H.M.S. 'Inconstant'       | 337.3      | 50.28      | 22.75        | .488             | .787                 | .614                  |
| { H.M.S. 'Volage'                                | 370.0      | 42.0       | 19.0         | .497             | .792                 | .625                  |
| Royal mail steamers { National Line              | 335.0      | 42.0       | 22.0         | .559             | .880                 | .800                  |
| { Peninsular and Oriental                        | 338.27     | 43.5       | 18.71        | .516             | .812                 | .635                  |
| { Anchor Line                                    | 350.0      | 35.0       | 21.0         | .687             | .850                 | .840                  |
| Troopships { H.M.S. 'Serapis'                    | 360.0      | 49.12      | 23.5         | .470             | .674                 | .700                  |
| { H.M.S. 'Himalaya'                              | 340.5      | 46.18      | 15.75        | .400             | .680                 | .582                  |
| Modern rigged ironclad, H.M.S. 'Hercules'        | 323.0      | 59.0       | 24.75        | .640             | .810                 | .710                  |
| Modern mastless ironclads { H.M.S. 'Devastation' | 285.0      | 62.25      | 26.5         | .684             | .809                 | .787                  |
| { H.M.S. 'Cyclops'                               | 225.0      | 45.0       | 15.0         | .715             | .932                 | .755                  |
| Composite gun boats { H.M.S. 'Ariel'             | 125.0      | 23.0       | 8.0          | .535             | .870                 | .616                  |
| { H.M.S. 'Sappho'                                | 160.0      | 31.33      | 12.0         | .468             | .745                 | .602                  |
| Small merchant vessels { from                    | 220.0      | 27.0       | 8.0          | .702             | .912                 | .742                  |
| { to   | 80.0       | 17.5       | 4.0          | .637             | .914                 | .704                  |



TABLE SHOWING METHOD OF COMPUTING A SHIP'S DISPLACEMENT, ETC., WHEN SUBDIVIDED INTERVALS ARE USED.

| DISPLACEMENT BY CENTERS OF BUOYANCY<br>VERTICAL SECTIONS BY VERTICAL SECTIONS |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |                     |                 |                 |                 |                 |                 |                   |                    |                |                            |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-------------------|--------------------|----------------|----------------------------|
| No. of<br>Sections  | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    | 13    | 14    | 15    | SIMPLEX MULTIPLIERS |                 |                 |                 |                 | Water<br>Line 5 | DISPLACEMENT      |                    | Lever-<br>ages | Products<br>for<br>Moments |
|   |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       | Water<br>Line 1     | Water<br>Line 2 | Water<br>Line 3 | Water<br>Line 4 | Water<br>Line 5 |                 | Area of<br>Funct. | Mult. of<br>Funct. |                |                            |
| 1   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100   | 100                 | 100             | 100             | 100             | 100             | 100             | 100               | 100                | 100            | 100                        |
| 2   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200   | 200                 | 200             | 200             | 200             | 200             | 200             | 200               | 200                | 200            | 200                        |
| 3   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300   | 300                 | 300             | 300             | 300             | 300             | 300             | 300               | 300                | 300            | 300                        |
| 4   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400   | 400                 | 400             | 400             | 400             | 400             | 400             | 400               | 400                | 400            | 400                        |
| 5   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500   | 500                 | 500             | 500             | 500             | 500             | 500             | 500               | 500                | 500            | 500                        |
| 6   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600   | 600                 | 600             | 600             | 600             | 600             | 600             | 600               | 600                | 600            | 600                        |
| 7   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700   | 700                 | 700             | 700             | 700             | 700             | 700             | 700               | 700                | 700            | 700                        |
| 8   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800   | 800                 | 800             | 800             | 800             | 800             | 800             | 800               | 800                | 800            | 800                        |
| 9   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900   | 900                 | 900             | 900             | 900             | 900             | 900             | 900               | 900                | 900            | 900                        |
| 10  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000  | 1000                | 1000            | 1000            | 1000            | 1000            | 1000            | 1000              | 1000               | 1000           | 1000                       |
| 11  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100  | 1100                | 1100            | 1100            | 1100            | 1100            | 1100            | 1100              | 1100               | 1100           | 1100                       |
| 12  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200  | 1200                | 1200            | 1200            | 1200            | 1200            | 1200            | 1200              | 1200               | 1200           | 1200                       |
| 13  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300  | 1300                | 1300            | 1300            | 1300            | 1300            | 1300            | 1300              | 1300               | 1300           | 1300                       |
| 14  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400  | 1400                | 1400            | 1400            | 1400            | 1400            | 1400            | 1400              | 1400               | 1400           | 1400                       |
| 15  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500  | 1500                | 1500            | 1500            | 1500            | 1500            | 1500            | 1500              | 1500               | 1500           | 1500                       |
| Functions of Areas  | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000               | 10000           | 10000           | 10000           | 10000           | 10000           | 10000             | 10000              | 10000          | 10000                      |
| Mults. of Functions   | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000               | 10000           | 10000           | 10000           | 10000           | 10000           | 10000             | 10000              | 10000          | 10000                      |
| Products for Moments  | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000               | 10000           | 10000           | 10000           | 10000           | 10000           | 10000             | 10000              | 10000          | 10000                      |

(Continued on next page.)





## EXPLANATION OF DISPLACEMENT SHEET. (See pp. 156 and 157.)

The length of the ship at water-line 5 is divided into 14 equal intervals, and the depth or draught of water\* into 4 equal intervals, the lower two being subdivided into half-intervals (for multipliers for subdivided intervals see pp. 89 and 40). The ordinates, or half-breadths, at the intersections of the vertical cross sections with the horizontal sections are measured off in feet, and set down in *dark* figures in rows *opposite* their respective cross sections and *under* their respective horizontal sections, thus forming the numbers into columns.

Each of the ordinates in the several *columns* are then multiplied by the 'Simpson's multiplier' at the head of their column, the products being set immediately below in *lighter* figures, and their sums taken in *rows* and placed to the right in the column headed 'functions of areas.'

Each of these 'functions of areas' is then multiplied by the 'Simpson's multiplier' proper to its *row*, the products being placed to the right in the column headed 'multiples of functions,' and their sum taken.†

Then, as a check upon the last result, it is usual to multiply each of the ordinates in the several *rows* by the 'Simpson's multiplier' to the left of their respective rows, the products being set in the adjoining *column* in *lighter* figures, and their sums taken in *columns* and placed below in the *row* of 'functions of areas.' †

Each of these 'functions of areas' is then multiplied by the 'Simpson's multiplier' proper to its *column*, the products being placed below in the *row* of 'multiples of functions.' The sum total of these 'multiples of functions' should then exactly correspond to the sum total of the *column* of 'multiples of functions,' thus proving the correctness of the calculations thus far. The latter sum is then multiplied by  $\frac{1}{3}$  of the vertical interval, and this again by  $\frac{1}{3}$  of the horizontal interval between the ordinates. This last product is then multiplied by 2 for both sides of the ship, and the result divided by 35 (that being the number of cubic feet of salt water in a ton), which gives the total displacement of the ship in tons to water-line 5.

The *horizontal* distance of the 'centre of buoyancy' abaft the stem, or No. 1 section, is then found by multiplying each of the products in the *column* headed 'multiples of functions' by its multiplier for leverage (that being the number of intervals the cross section is distant from No. 1 section), the products being placed in the *column* headed 'products for moments.' The sum total of these divided by the sum of the *column* of 'multiples of areas,' and the quotient multiplied by the *horizontal* interval, will give the distance of the centre of buoyancy abaft No. 1 section in feet. The *vertical* distance of the 'centre of buoyancy' below water-line 5 is found by multiplying each of the products in the *row* of 'multiples of functions' by its multiplier for leverage (that being the number of intervals the horizontal section is from water-line 5), the products being placed below in the *row* of 'products for moments.' The sum total of these divided by the sum of the *row* of multiples of areas, and the quotient multiplied by the *vertical* interval, will give the vertical distance of the centre of buoyancy below water-line 5 in feet.

\* Should the vessel have a bar keel, the depth should be taken from top of keel.

† These numbers are only *proportional* to the areas of the vertical or horizontal sections; but to find the absolute values of the areas of any of these sections the numbers must be multiplied by  $\frac{1}{3}$  the distance between the ordinates, and that product by 2 for both sides.

## TO CALCULATE THE POSITION OF THE CENTRE OF GRAVITY OF A SHIP'S HULL.

*To find the centre of gravity of a ship's hull relatively to any fixed plane (see p. 161).*

**RULE.**—Find the moments of the component parts of the ship's hull relatively to the given plane by multiplying the weight of each part by the perpendicular distance of its centre of gravity from that plane; then find the resultant of those moments by adding together separately the positive and negative moments (or right- and left-handed moments), and taking the difference between the two sums; the resultant will be positive or negative, according to which moments are the greater. Divide the result thus found by the total weight of the hull of the ship; the product will be the perpendicular distance of the centre of gravity from the given fixed plane.

As the centre of gravity of the hull of a ship is generally in the middle line, it is only necessary, as a rule, to determine its position relatively to two fixed planes, one being a transverse vertical plane and the other a horizontal plane, the midship transverse section and the load water-plane being generally taken as the two respective planes.

*To determine the position of the centre of gravity of the bottom plating of a ship's hull when of a uniform thickness throughout.*

1. *Determine its longitudinal position from a transverse vertical plane as follows (see p. 160):—*

**RULE.**—Measure the half-girths of the plating at equidistant stations, as if for measuring its area; integrate by means of a set of Simpson's multipliers, and add the results together; then multiply each of those functions of the half-girths in their consecutive order by the figure representing the number of intervals it is from the plane of moments. Find the resultant of those moments and divide it by the sum of the functions of the half-girths, and multiply the product by the common interval between the stations. The result will be the perpendicular distance of the centre of gravity from the given fixed plane.

2. *Determine its perpendicular distance from a fixed horizontal plane by the following rule, providing that all the centres of gravity of the half-girths are below the plane of moments (see p. 160):—*

**RULE.**—Measure the half-girths as before; integrate them by means of the same set of Simpson's multipliers, and add the results together; then multiply each of those functions of the half-girths in their consecutive order by the respective distance of its centre of gravity from the given plane; add together the products and divide the result by the sum of the functions of the half-girths: the result will be the perpendicular distance of the centre of gravity from the horizontal plane.

**N.B.** When the frames of a ship are of a uniform character, and are placed at equidistant intervals, their common centre of gravity may be determined in the same way by means of the two foregoing rules.

**TABLE SHOWING METHOD OF CALCULATING THE LONGITUDINAL POSITION OF THE CENTRE OF GRAVITY OF THE BOTTOM PLATING OF A SHIP'S HULL.**

| No. of Stations | Half-girths | Simpson's Mults. | Functions of Half-girths | Mults. for Moments | Products for Moments | No. of Stations |
|-----------------|-------------|------------------|--------------------------|--------------------|----------------------|-----------------|
| 1               | 21.0        | 1                | 21.0                     | 8                  | 168.0                | 1               |
| 2               | 27.2        | 4                | 108.8                    | 7                  | 761.6                | 2               |
| 3               | 30.8        | 2                | 61.6                     | 6                  | 369.6                | 3               |
| 4               | 34.6        | 4                | 138.4                    | 5                  | 692.0                | 4               |
| 5               | 38.8        | 2                | 77.6                     | 4                  | 310.4                | 5               |
| 6               | 41.5        | 4                | 166.0                    | 3                  | 498.0                | 6               |
| 7               | 42.6        | 2                | 85.2                     | 2                  | 170.4                | 7               |
| 8               | 44.0        | 4                | 176.0                    | 1                  | 176.0                | 8               |
| 9               | 44.0        | 1                | 44.0                     | 0                  | .0                   | 9               |
| 10              | 44.0        | 4                | 176.0                    | 1                  | 176.0                | 10              |
| 11              | 43.3        | 2                | 86.6                     | 2                  | 173.2                | 11              |
| 12              | 42.1        | 4                | 168.4                    | 3                  | 505.2                | 12              |
| 13              | 40.3        | 2                | 80.6                     | 4                  | 322.4                | 13              |
| 14              | 38.1        | 4                | 152.4                    | 5                  | 762.0                | 14              |
| 15              | 36.0        | 2                | 72.0                     | 6                  | 432.0                | 15              |
| 16              | 35.0        | 4                | 140.0                    | 7                  | 980.0                | 16              |
| 17              | 32.0        | 1                | 32.0                     | 8                  | 256.0                | 17              |

Sum of functions of half-girths 1830.6

1830.6 ) 460.8

.246

15

Distance of C. of Grav. towards No. 17 from No. 9 Station 3.690

**TABLE SHOWING METHOD OF CALCULATING THE VERTICAL POSITION OF THE CENTRE OF GRAVITY OF THE BOTTOM PLATING OF A SHIP'S HULL.**

| No. of Stations | Half-girths | Simpson's Mults. | Functions of Half-girths | Mults. for Moments | Products for Moments | No. of Stations |
|-----------------|-------------|------------------|--------------------------|--------------------|----------------------|-----------------|
| 1               | 21.0        | 1                | 21.0                     | .60                | 12.60                | 1               |
| 2               | 27.2        | 4                | 108.8                    | 1.25               | 136.00               | 2               |
| 3               | 30.8        | 2                | 61.6                     | 1.80               | 110.88               | 3               |
| 4               | 34.6        | 4                | 138.4                    | 2.10               | 290.64               | 4               |
| 5               | 38.8        | 2                | 77.6                     | 2.25               | 174.60               | 5               |
| 6               | 41.5        | 4                | 166.0                    | 2.30               | 381.80               | 6               |
| 7               | 42.6        | 2                | 85.2                     | 2.35               | 200.22               | 7               |
| 8               | 44.0        | 4                | 176.0                    | 2.40               | 422.40               | 8               |
| 9               | 44.0        | 2                | 88.0                     | 2.41               | 212.08               | 9               |
| 10              | 44.0        | 4                | 176.0                    | 2.41               | 424.16               | 10              |
| 11              | 43.3        | 2                | 86.6                     | 2.40               | 207.84               | 11              |
| 12              | 42.1        | 4                | 168.4                    | 2.35               | 395.74               | 12              |
| 13              | 40.3        | 2                | 80.6                     | 2.30               | 185.38               | 13              |
| 14              | 38.1        | 4                | 152.4                    | 2.25               | 342.90               | 14              |
| 15              | 36.0        | 2                | 72.0                     | 2.05               | 147.60               | 15              |
| 16              | 35.0        | 4                | 140.0                    | 1.50               | 210.00               | 16              |
| 17              | 32.0        | 1                | 32.0                     | .75                | 24.00                | 17              |

1830.6

1830.6 ) 8878.84

Distance of Centre of Gravity below Longitudinal Plane 2.118



## STABILITY.

## STATICAL STABILITY.

*Statical stability is defined to be the moment of force by which a floating body endeavours to gain its upright position, or position of equilibrium, after having been deflected from it.*

FIG. 131.

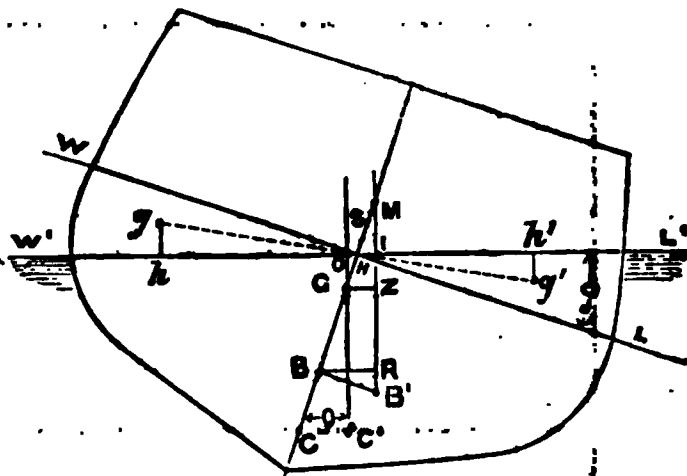


Fig. 131 is a transverse section of a ship heeled over through a certain angle  $\theta$ .  $W'L'$  is the water-line for the inclined position, and  $WL$  is the water-line for the upright position. These two planes intersect each other in a longitudinal direction, and bound two wedges  $L'SL$  and  $WSW'$  equal in volume to each other, provided the displacement remains the same. The wedges are called respectively the wedges of *immersion* and *emersion*, or the *in* and *out* wedges.  $G$  is the centre of gravity of the ship, and  $B'$  her centre of gravity of displacement, or centre of buoyancy. The weight of the ship then acts vertically downwards through  $G$ , and the resultant pressure of the water acts vertically upwards through  $B'$ , these two forces forming a *righting couple*, the arm of which is  $GZ$ —that is, the perpendicular distance between the lines of action of the two forces. The moment of this couple—that is, the weight of the ship, or its displacement, multiplied by the length of the arm  $GZ$ —is the *moment of statical stability* of the ship at the given angle of inclination  $\theta$ . This moment is generally expressed in *foot tons*—that is, the weight of the ship in tons multiplied by the length of the arm  $GZ$  in feet.  $B$  is the centre of buoyancy of the ship when upright;  $S$  is the point of intersection of the two water-lines,  $I$  the point where the vertical  $B'M$  cuts the plane of flotation;  $g$  and  $g'$  are the centres of gravity of the emerged and immersed wedges respectively,  $gh$  and  $g'h'$  being perpendiculars dropped to  $g$  and  $g'$  from the plane of flotation  $W'L'$ . The point  $M$ , where the vertical line  $BM$ , drawn through the centre of buoyancy  $B$  when the ship is in an upright position, cuts the vertical line  $B'M$ , drawn through the centre of buoyancy  $B'$  for the inclined position, is termed the *transverse metacentre* when the ship is inclined through an indefinitely small angle, and also when the point of intersection is the same for all angles of heel.

When the position varies for the different angles of heel, it is termed a *shifting metacentre*.

When the ship is inclined longitudinally, it is called the *longitudinal metacentre*.

During the inclination of the ship the centre of buoyancy moved from B to B', and B' lies in a plane parallel to a line joining g and g'. The distance BB' can be found from the following expression:—

$$BB' = \frac{V \times gg'}{D},$$

where D = volume of displacement and V = volume of either of the wedges;

$$BR = \frac{V \times hh'}{D}, \text{ where BR is perpendicular to B'M;}$$

and 
$$GZ = BR - BG \cdot \sin \theta = \frac{V \times hh'}{D} - BG \cdot \sin \theta,$$

whence Atwood's formula for expressing the *moment of statical stability* at any angle  $\theta$  is

$$\begin{aligned} M &= (V \times hh') - (D \times BG \cdot \sin \theta) \\ &= D \frac{(V \times hh')}{D} - (BG \cdot \sin \theta). \end{aligned}$$

The moment of *statical surface stability* at any angle  $\theta$  is  $BR \times D$ ; being what the righting moment would be, supposing the centre of gravity of the ship coincided with B. The angle of heel in fig. 131 is  $BMB' = \angle SL^h$ , and its sine is equal to  $\frac{BR}{BM} = \frac{GZ}{GM}$ .

The *coefficient* of a ship's stability at any angle of heel is expressed when the displacement is multiplied by the vertical height of the metacentre for the given angle of heel above the centre of gravity.

That is, the coefficient of a ship's stability at any angle  $\theta$

$$= D \times GM = D(BM - BG)$$

$$BM = \frac{V \times hh'}{D \cdot \sin \theta}.$$

BR is said to be the *lever of statical surface stability*.

When M lies above G the vessel is *stable*; if too high, the vessel is *uneasy*; when below, the vessel is *unstable*; and when it coincides with G, the equilibrium is said to be *neutral*.

The point M in vessels of the common type is usually calculated for the upright position, as it generally remains a fixed point for the first 10 or 15 degrees of heel, when it is useful for comparing the *initial surface stability* of different vessels.

To calculate the height of the metacentre above the centre of buoyancy see pp. 155 and 175.

### DYNAMICAL STABILITY.

*Dynamical stability is defined to be the amount of mechanical work necessary to cause a body to deviate from its upright position, or position of equilibrium.*

Dynamical stability is expressed as a moment by multiplying the sum of the vertical distances through which the centre of gravity of the ship ascends and the centre of buoyancy descends, in moving from the upright to the inclined position, by the weight of the ship, or displacement.

In fig. 131 during the inclination of the ship through the angle  $\theta$ , the centre of gravity has been moved through a vertical height  $GH - GO$ , and the centre of buoyancy has been lowered through a vertical distance  $B'I - BH$ , and the whole work to do this, or her moment of dynamical stability for the given angle  $\theta$ , is

$$\begin{aligned} &= D \{ (GH - GO) + (B'I - BH) \} \\ &= D(B'Z - BG) = D(B'R - BG \cdot \text{vers } \theta) \\ &= D \left( \frac{V(gh + g'h')}{D} - BG \cdot \text{vers } \theta \right); \end{aligned}$$

whence Moseley's formula for the moment of dynamical stability at any angle  $\theta$  is

$$= V(gh + g'h') - (D \times BG \cdot \text{vers } \theta).$$

The dynamical stability of a ship at any angle  $\theta$  is the *integral* of its statical stability at the given angle—that is, if  $M$  = the statical stability and  $U$  the dynamical stability, then

$$U = \int M d\theta,$$

where  $d\theta$  is a very small angle of heel.

The *moment of dynamical surface stability* is expressed by multiplying the weight of the ship, or displacement, by the depression of the centre of buoyancy during the inclination—that is, for the angle  $\theta$

$$U = D(B'I - BH).$$

#### RULES CONNECTED WITH STABILITY.

1. *To find approximately the moment of statical surface stability per foot of length of a vessel at any small angle of heel.*

RULE.—Cube the half-breadth of the vessel and multiply it by the sine of the angle of heel; two-thirds of the product will be the required result.

This result is expressed as follows when  $B$  = half-breadth of vessel:—

$$\frac{2}{3}(B^3 \times \sin \theta).$$

2. *To find approximately the surface stability of a vessel for any small angle of heel.*

RULE.—Divide the moment of inertia of the plane of flotation for the upright position relatively to the middle line by the volume of displacement; the quotient multiplied by the sine of the angle of heel will be the required result.

Or it may be expressed more fully as follows:—

Divide the length of the plane of flotation, or water-line, for the upright position into a number of equal intervals,

and measure the half-breadths at the points of division; cube those half-breadths and treat them as if they were ordinates of a new curve of the same length as the plane of flotation: two-thirds of the area of the new curve, found by a proper rule, will be the moment of inertia of the plane of flotation relatively to the middle line. This moment of inertia multiplied by the sine of the angle of heel will be the required result. It is usually expressed in algebraical symbols thus:—

$$\frac{2 \sin \theta}{3} \int y^2 dx.$$

*Note.*—The two foregoing rules are exact for any angle of heel if the metacentre remains fixed for the different angles, and therefore remains also true for any angle of heel when the moment of inertia of the plane of flotation due to the angle of heel can be found.

3. To find the height of the metacentre above the centre of buoyancy for the upright position.

**RULE.**—Divide the moment of inertia of the plane of flotation relatively to the middle line by the volume of the displacement. In algebraical symbols it is expressed as follows:—

$$BM = \frac{\int y^2 dx}{D}.$$

*Note.*—For moment of inertia see Rule 2, p. 164, also p. 79.

4. To find approximately the dynamical stability of a vessel at any given angle of heel.

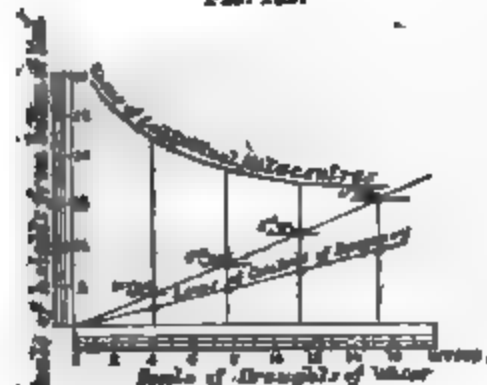
**RULE 1.**—Multiply the displacement by the height of the metacentre above the centre of gravity, and that product by the versed sine of the angle of heel.

**RULE 2.**—Multiply the statical stability for the given angle by the tangent of one-half of the angle of heel.

### CURVES OF STABILITY.

The *Metacentric Curve*, or *Curve of Metacentres*, is a curve used to determine approximately the initial statical surface stability

FIG. 132.



a vessel has at any draught of water parallel to her constructed load draught.

*Method of Construction.*—

Calculate the height of the ship's metacentre from the under side of keel for several successive draughts of water parallel to her constructed load draught; set those heights off as ordinates (see fig. 132) from a base line the abscissae of which represent to scale the respective draughts of water: a curve bent through the extremities of these ordinates will form the metacentric curve:



*The Curve of Statical Stability* is a curve used to determine the exact statical stability of a vessel at any given angle of heel.

FIG. 133.

CURVE OF STATICAL STABILITY OF AN IRONCLAD WITH HIGH FREEBOARD.

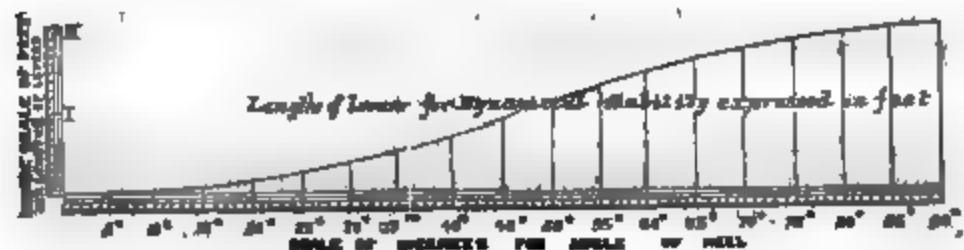


**Method of Construction.**—Calculate the length of the arm of the righting couple, or  $GZ$  (see fig. 131), for several successive angles of heel taken between the upright position and that at which the length of the arm becomes zero; set the lengths of these arms off as ordinates (see fig. 133) from a base line the abscissæ of which represent to scale the respective angles of heel: a curve bent through the extremities of these ordinates will form a curve of statical stability.

*The Curve of Dynamical Stability* is constructed in a similar manner to that of the curve of statical stability, with the exception that the various lengths of the arm ( $B'E - BG$ ) = ( $B'E - BG$  vers  $\theta$ ), (see fig. 131), are taken as ordinates instead of  $GZ$ .

FIG. 134.

CURVE OF DYNAMICAL STABILITY OF AN IRONCLAD WITH HIGH FREEBOARD.



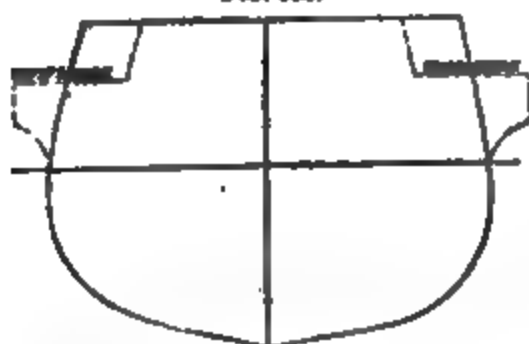
*Curves of Statical and Dynamical Surface Stability* are also constructed in a similar manner to the foregoing curves, the lengths of the arms  $BR$  and  $B'I - BH$  (see fig. 131) being taken as ordinates for the respective curves.

#### TO CALCULATE THE STATICAL AND DYNAMICAL STABILITIES OF A VESSEL AT SUCCESSIVE ANGLES OF HEEL:

1. *Body Plan* (fig. 136).—Prepare a body plan in which all the sections are taken perpendicular to the load water-line, and at equal distances apart. In constructing it the sections should be made fair continuous curves, any irregularities

which might be caused by embrasures, &c., being left out

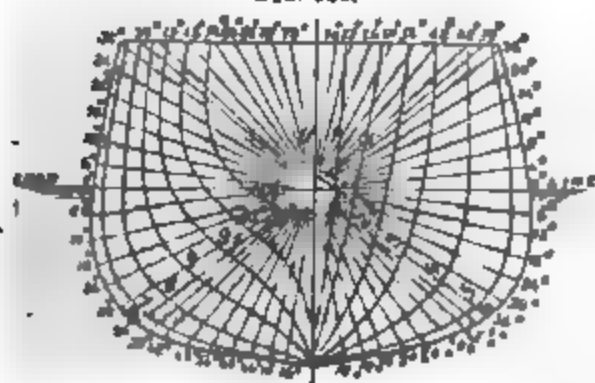
FIG. 134.



(as shown in full lines in fig. 135, where the dotted lines show the actual section of vessel), they being treated separately afterwards as *appendages*. When there are appendages it is also necessary to have correct sheer and half-breadth draughts, in order to calculate their volume, &c.

2. *Angular Interval*.—The body plan has now to be crossed

FIG. 135.



by a number of lines, radiating from the middle point of the load water-plane, and at equiangular intervals, taking care that one passes through the edge of the upper continuous deck amidships.

The equiangular interval is determined as follows:—Divide the angle which the radiat-

ing line, passing through the edge of the upper deck, makes with the load water-line, into such a number of equiangular intervals that the line passing through the edge of the upper deck becomes a stop-point in the integration to which these radiating lines will be afterwards treated. If Simpson's first rule is used the number of intervals must be even; if his second rule, a multiple of three must be used, and so on. The angular interval should not be more than  $10^\circ$  or less than  $3^\circ$ .

It is usual to introduce an intermediate radiating line at half an interval after the edge of the deck has been passed, in order to reduce the error caused by applying Simpson's rule to so discontinuous a surface as the upper deck.

3. *Measuring the Ordinates*.—The ordinates of the immersed and emerged sides of the various inclined longitudinal water-planes are measured off right fore and aft for each successive angle of heel from the middle line of the ship, and entered upon a set of tables, styled *preliminary tables*, under their proper heading. One of these tables is necessary for each separate angle of heel.

4. *Preliminary Tables* (see p. 176).—Three operations are performed upon the ordinates entered in these tables. Firstly, they are affected by a set of Simpson's multipliers, in order

to find a function for the *area* of the immersed and emerged sides of the respective radial planes. Secondly, the squares of the ordinates are affected by the same set of multipliers in order to find a function for the *moment* of the immersed and emerged sides of the respective radial planes. Thirdly, the cubes of the ordinates are affected by the same set of multipliers in order to find a function for the *moment of inertia* of the immersed and emerged sides of the various radial planes about the middle line of ship.

5. *Combination Tables* (see p. 177).—The results obtained in the preliminary tables are made use of in these tables to determine—

(1st) The area of the various inclined water-planes, together with their centres of gravity.

(2nd) The volumes of the assumed wedges of immersion and emersion.

(3rd) The position of the true water-planes at the different angles of heel.

(4th) The moments of the corrected wedges of immersion and emersion.

6. *Areas of the Inclined Water-planes*.—The area of an inclined water-plane is easily found for any angle of heel by adding together the sums of the functions of the ordinates for the immersed and emerged sides of the respective water-planes, and multiplying the result by  $\frac{1}{3}$  the longitudinal interval if Simpson's first rule is used.\*

7. *Centre of Gravity of the Inclined Water-planes*.—To find the distance of the centre of gravity of any inclined water-plane relatively to the middle line of the ship, proceed as follows:—Take the difference between the sums of the functions of the squares of the ordinates for the immersed and emerged sides of the water-plane; divide the result by 2 and multiply the quotient by  $\frac{1}{3}$  the longitudinal distance between the ordinates, if Simpson's first rule is used. That product divided by the area of the water-plane will give the distance of its centre of gravity from the middle line.

8. *Volumes of Assumed Wedges*.—Take the sums of the functions of the squares of the ordinates for both sides of each of the radial planes contained in the wedges of immersion and emersion, and enter them in their proper column in the combination table, and affect them by a proper set of multipliers; add their results together, subtract the lesser sum from the greater, and divide the result by 2. The quotient multiplied by  $\frac{1}{3}$  the longitudinal distance between the ordinates, if Simpson's first rule is used (this division by 3 is generally done in the preliminary tables): this final product multiplied by  $\frac{1}{3}$  of the equiangular interval in circular measure, if Simpson's first rule is again

\* *Note*.—The division by 3 is generally done in the preliminary tables.

used, will give the difference between the volumes of the assumed wedges of immersion and emersion. If there are any appendages the necessary additions or deductions are made here.

9. *Correcting Layer*.—If the volume of the assumed wedge of immersion exceeds that of the wedge of emersion, it shows that the displacement up to the radial plane is too great, and that to find the true water-plane a parallel layer must be taken away from the assumed wedge of immersion; but if the wedge of emersion exceeds that of immersion, a parallel layer must be added to the wedge of immersion.

The *thickness* of this layer is found by dividing the difference between the volumes of the two assumed wedges by the area of the proper radial water-plane, having made any additions or deductions in the case of appendages.

10. *Moments of Wedges for Statical Stability*.—The sums of the functions of the cubes of the ordinates for both the immersed and emerged wedges are placed in the proper column in the combination table, and are affected by the same set of multipliers as were determined for the sums of the functions of the squares; the products are multiplied by the various cosines of the angles of inclination made by the radial planes with the load water-line; the products are then added together and the sum divided by 3; the quotient is then multiplied by  $\frac{1}{3}$  the angular interval, and that product by  $\frac{1}{3}$  the longitudinal interval, between the ordinates, if Simpson's first rule has been used (this division by 3 is generally done in the preliminary tables): the final result will be the moment of the wedges about a line perpendicular to the radial plane, and passing through the middle point of the load water-plane. The corrections for the moments of the appendages must now be added or subtracted, as the case may be, also the correction for the layer, if any, must be done here, its moment being found by multiplying its volume by the distance of the centre of gravity of its water plane from the middle point of the load water-plane. If the centre of gravity of the layer lies towards that side for which the assumed wedge is the greater, the correction must be deducted; if it lies towards the opposite side, it must be added. This final result, being divided by the total volume of displacement, will give the length of the arm BR (see fig. 131). Multiply the height of the centre of gravity above the centre of buoyancy by the sine of the angle of heel, and subtract the product from BR; the remainder will be the length of the arm of the righting couple GZ; GZ multiplied by the displacement in tons will give the righting moment, or statical stability, of the ship for the given angle of heel.

11. *Moments of the Wedges for Dynamical Stability*.—This result is determined in a manner somewhat similar to that pursued for the statical stability, the only difference being that the

sums of the functions of the cubes are multiplied by the sines of the various angles of inclination instead of the cosines; the sum of the products so obtained being divided and multiplied by the same numbers as were used for the statical stability, in order to find the moment of the wedges uncorrected relatively to the respective radial planes. The corrections for the appendages are then made, that for the correcting layer being subtracted in all cases. The moment for the correcting layer is found by multiplying its volume by half its thickness, that being about the vertical height of its centre of gravity from its radial plane. This final result divided by the total volume of displacement will give the length of the arm B'R, from which if BG . vers  $\theta$  be deducted, the remainder will equal the length of the arm for the dynamical stability, or the vertical height through which the centre of gravity of the ship has been lifted and the centre of buoyancy depressed.

12. *Geometrical Mode of Calculating Dynamical Stability.*—The dynamical stability of a vessel at any given angle of heel is the sum of the moments of the statical stability taken at indefinitely small equiangular intervals up to the given angle of heel, and is therefore equal to the area of the curve of statical stability included between the origin of the curve and the angle in question. It must be noticed that the abscissæ of a curve of statical stability is given in angles, and therefore the longitudinal interval is taken in circular measure.

But, as the lengths of the arms for statical stability are generally used to construct a curve instead of the moments of stability, the area, as above found by the rule from such a curve, will necessarily give the length of the arm for dynamical stability and not the moment.

*Example* (see fig. 133).—To find the length of the arm for dynamical stability at an angle of 30° inclination.

| Angles of Heel | Lengths of Statical<br>Levers az | Simpson's<br>Multipliers | Products |
|----------------|----------------------------------|--------------------------|----------|
| 0 degrees      | ·0                               | 1                        | ·0       |
| 5     "        | ·2                               | 4                        | ·8       |
| 10    "        | ·42                              | 2                        | ·84      |
| 15    "        | ·68                              | 4                        | 2·72     |
| 20    "        | ·97                              | 2                        | 1·94     |
| 25    "        | 1·30                             | 4                        | 5·20     |
| 30    "        | 1·66                             | 1                        | 1·66     |

13·16

$\frac{1}{3}$  of angular interval in circular measure = ·0291

1316

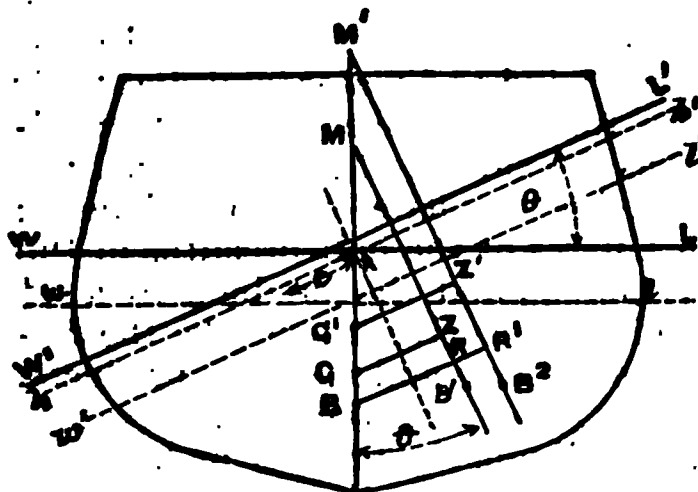
11844

2632

Dynamical lever for 30° = ·382956

13. *Curve of Stability for Light Draught.*—The lengths of the arms for this curve can readily be approximated from the results obtained for the curve in the load condition.

FIG. 137.



In fig. 137 WL is the load water-line, and wl the light water-line, for the upright position of the vessel. If the vessel is inclined through an angle  $\theta$ , and W'L' is the true position of the inclined water-plane for the load condition, then the true position of the water-plane for the light condition will run parallel to

it, as w'l'. To determine its perpendicular distance from W'L', divide the volume of the layer contained between the light and load water-planes by the area of the assumed inclined water-plane  $hh'$ , which was found for the inclined load condition. Let B be the centre of buoyancy for the upright load condition, B' for the inclined load condition, and B'' for the inclined light condition. BB is perpendicular to the vertical B'M, and BB' is perpendicular to the vertical B''M'.

Let D equal volume of light displacement.

„  $d$  = volume of displacement contained between the light and load water-planes.

„  $c$  = distance of centre of gravity of assumed inclined water-plane from the vertical through A.

„ GZ and G'Z' = the lengths of the arms of the righting couples for the load and light condition respectively.

$$\text{Then } BB' = \frac{d\{c + (BB - BA \cdot \sin \theta)\}}{D} \quad BB' = BB + BB',$$

$$\text{and } G'Z' = BB' - BG' \cdot \sin \theta.$$

*Surface of Flotation.*—If a ship be inclined through an unlimited number of indefinitely small angles in every possible direction, a curved surface touching all the planes of flotation thus made is called a surface of flotation, and the point of its contact with any water-plane is the centre of gravity of that plane.

*Axis of Level Motion.*—When the transverse section of a surface of flotation is a circle, the centre of that circle is termed the axis of level motion. This axis lies parallel to the load water-line, and is in the longitudinal middle-line vertical plane of the ship for the upright position, and is so placed as to

keep the same position, when the vessel is heeled over to any angle, as when she was upright.

*To determine approximately the height of the axis of level motion above the plane of flotation.*

**RULE.**—Measure the angles of inclination of the several cross sections to the vertical between wind and water, and find their tangents, distinguishing those tangents respectively into positive and negative, according as the side of the section inclines outward or inward (that is, having any flare or tumble-home); multiply the tangents by the squares of the half-breadths of the cross sections to which they belong, and the products by a set of Simpson's multipliers in their consecutive order; take the difference between the sums of the positive and negative products, and multiply the difference by  $\frac{1}{3}$  the longitudinal interval (if Simpson's first rule is used), and divide the product by half the area of the water-plane: the quotient will be the required result.

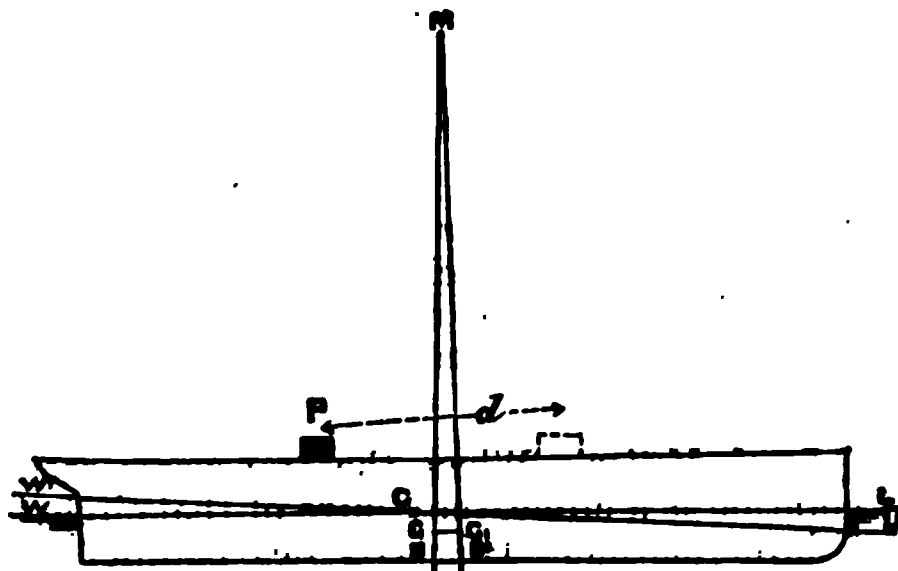
#### LONGITUDINAL METACENTRE AND ALTERATION OF TRIM.

*To determine the vertical height of the longitudinal metacentre above the centre of buoyancy.*

**RULE.**—Divide the moment of inertia of the load water-plane, relatively to a transverse axis passing through the centre of the plane of flotation, by the volume of displacement. (For example of calculation see p. 174.)

The following method will generally be found in practice to be the simplest for finding the moment of inertia of the plane of flotation relatively to the transverse axis through the plane of flotation:—First determine the moment of inertia of the given plane relatively to one of its ordinates as a transverse axis (see Rule 7, p. 79); then from the result subtract the area of the plane multiplied by the square of the distance of its centre from the given axis.

FIG. 138.



*Moment to Alter the Trim of a Vessel.*—In fig. 138 let WL be the original load water-line, W'L' the load-line to which it is

required to trim the vessel, C the centre of flotation and the point at which the two load-lines intersect each other.

The total alteration of trim =  $WW' + LL'$ .

Let G be the position of the centre of gravity, B the centre of buoyancy, for the upright position, G' and B' the altered positions of the centres due to the alteration in trim, and M the longitudinal metacentre; let P = the weight on board that has to be moved,  $d$  = the horizontal distance through which the weight has to be moved to produce the required trim, and D = the displacement of the ship in tons: then

$$BB' = \frac{(WW' + LL') BM}{WL},$$

$$GG' = \frac{(WW' + LL') GM}{WL} = \frac{P \times d}{D};$$

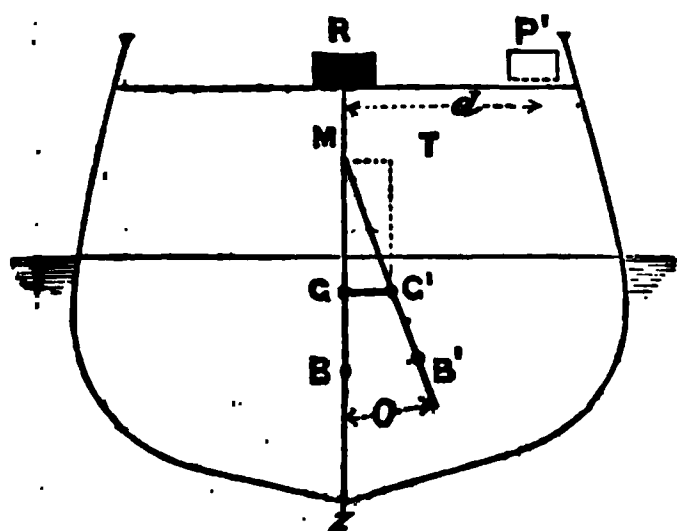
$$\text{also } WW' = \frac{WC(P \times d)}{GM \times D}, LL' = \frac{LC(P \times d)}{GM \times D}, \text{ and } WW' + LL' = \frac{WL(P \times d)}{GM \times D}.$$

$$\text{Moment to alter trim one inch} = \frac{D}{12} \times \frac{GM}{WL}.$$

$$\text{Moment to alter trim } n \text{ inches} = n \times \frac{D}{12} \times \frac{GM}{WL}.$$

### TO DETERMINE THE VERTICAL POSITION OF A SHIP'S CENTRE OF GRAVITY BY EXPERIMENT.

FIG. 139.



In fig. 139 let MZ be the upright axis of a ship; her centre of gravity then lies somewhere in that axis. M is the metacentre, and GM its vertical height above the centre of gravity G.

If a weight P be moved transversely through a distance  $PP' = d$ , it will heel the vessel over through an angle  $\theta$ , and her centre of gravity will then shift in a direction  $GG'$  parallel to that

in which the centre of gravity of the weight has been shifted. Let MT be parallel to  $GG'$  and  $TG'$  parallel to  $GM$ ; let P = weight shifted in tons, and D = displacement of ship in tons: then

$$MT = GG' = \frac{P \times d}{D}, \text{ and } GM = GG' \cotan \theta = \frac{P \times d}{D} \cotan \theta.$$

*Note.*—If several weights are shifted the total sum of each of the moments must be taken.



# CALCULATION OF HEIGHT OF LONGITUDINAL METACENTRE ABOVE CENTRE OF BUOYANCY, AND MOMENT TO ALTER TRIM ONE INCH.

| Nos. of Ordinates | Ordinates | Simpson's Multipliers | Products for Area | Multa. for Moments | Products for Moments | Multa. for Moments of Inertia | Products for Moments of Inertia | Nos. of Stations |
|-------------------|-----------|-----------------------|-------------------|--------------------|----------------------|-------------------------------|---------------------------------|------------------|
| 1                 | 1         | $\frac{1}{3}$         | 05                | 0                  | 0                    | 0                             | 0                               | 1                |
| 1 $\frac{1}{2}$   | 3.6       | 2                     | 7.20              | $\frac{1}{2}$      | 3.60                 | $\frac{1}{2}$                 | 1.80                            | 1 $\frac{1}{2}$  |
| 2                 | 7.1       | 1                     | 7.10              | 1                  | 7.10                 | 1                             | 7.10                            | 2                |
| 2 $\frac{1}{2}$   | 9.5       | 2                     | 19.00             | 1 $\frac{1}{2}$    | 28.50                | 1 $\frac{1}{2}$               | 42.70                           | 2 $\frac{1}{2}$  |
| 3                 | 11.6      | 1 $\frac{1}{2}$       | 17.40             | 2                  | 34.80                | 2                             | 69.60                           | 3                |
| 4                 | 13.7      | 4                     | 54.80             | 3                  | 164.40               | 3                             | 493.20                          | 4                |
| 5                 | 14.3      | 2                     | 28.60             | 4                  | 114.40               | 4                             | 457.60                          | 5                |
| 6                 | 14.4      | 4                     | 57.60             | 5                  | 288.00               | 5                             | 1440.00                         | 6                |
| 7                 | 14.4      | 2                     | 28.80             | 6                  | 172.80               | 6                             | 1036.80                         | 7                |
| 8                 | 14.4      | 4                     | 57.60             | 7                  | 403.20               | 7                             | 1422.40                         | 8                |
| 9                 | 14.2      | 2                     | 28.40             | 8                  | 227.20               | 8                             | 1817.60                         | 9                |
| 10                | 13.8      | 4                     | 55.20             | 9                  | 496.80               | 9                             | 4471.20                         | 10               |
| 11                | 13.4      | 1 $\frac{1}{2}$       | 20.10             | 10                 | 201.00               | 10                            | 2010.00                         | 11               |
| 11 $\frac{1}{2}$  | 11.1      | 2                     | 22.20             | 10 $\frac{1}{2}$   | 233.10               | 10 $\frac{1}{2}$              | 2447.55                         | 11 $\frac{1}{2}$ |
| 12                | 8.4       | 1                     | 8.40              | 11                 | 92.40                | 11                            | 1016.40                         | 12               |
| 12 $\frac{1}{2}$  | 4.4       | 2                     | 8.80              | 11 $\frac{1}{2}$   | 101.20               | 11 $\frac{1}{2}$              | 1163.80                         | 12 $\frac{1}{2}$ |
| 13                | 2         | $\frac{1}{3}$         | 10                | 12                 | 1.20                 | 12                            | 14.40                           | 13               |

421.35

2569.70

17912.15

 $\frac{1}{3}$  Long. Interval

5.7

17.1

Long. Int. 17.1

2401.695

43941.87

306297.765

2

Long. Int. 17.1

Cu. ft. in aton 35) 4803.39

5237691.7815

12) 137.239

Long. Int. 17.1

Dispt. per inch 11.436

3) 89564529.46365

29854843.15455

2

Moment of Inertia about No. 1 Ordinate 59709686.30910

Area of Load Water-plane  $\times (104.2)^2$  52153479.39960

Volume of Displacement in cub. feet .18291) 7556206.90950

Height of Long. Metacentre above Centre of Buoy. 413.1

Height of C. of Grav. of ship above Centre of Buoy. 2.73

Height of Long. Metacentre above C. of G. of ship. 410.37

421.35) 43941.87

Distance of C. of Flotation from No. 1 Ordinate 104.2

Moment to alter trim one inch =  $\frac{410.37}{205} \times \frac{522\frac{1}{2}}{12} = 87.04$  foot tons.

\* Length of ship at L. W. Line = 205 ft.

† Dispt. of ship in tons = 522.

TABLE SHOWING METHOD OF CALCULATING THE HEIGHT OF TRANSVERSE METACENTRE ABOVE CENTRE OF BUOYANCY AT EQUIDISTANT PARALLEL DRAUGHTS OF WATER, IN ORDER TO CONSTRUCT A METACENTRIC CURVE, OR CURVE OF METACENTRES.\*

| 5th WATER-PLANE                                 |       |        |           | 3rd WATER-PLANE |       |        |           | 1st WATER-PLANE |       |        |           | LOAD WATER-PLANE |   |        |           | No. of Stations |  |  |
|---|-------|--------|-----------|-----------------|-------|--------|-----------|-----------------|-------|--------|-----------|------------------|---|--------|-----------|-----------------|--|--|
| Ord.  | Cubes | Mults. | Functions | Ord.            | Cubes | Mults. | Functions | Ord.            | Cubes | Mults. | Functions | Ord.             | Cubes   | Mults. | Functions | Station         |  |  |
| 1   | 1     | 1      | 1         | 1               | 1     | 1      | 1         | 1               | 1     | 1      | 1         | 1                | 1   | 1      | 1         | 1               |  |  |
| 2   | 8     | 4      | 24        | 2               | 8     | 4      | 24        | 2               | 8     | 4      | 24        | 2                | 8   | 4      | 24        | 2               |  |  |
| 3   | 27    | 9      | 81        | 3               | 27    | 9      | 81        | 3               | 27    | 9      | 81        | 3                | 27  | 9      | 81        | 3               |  |  |
| 4   | 64    | 16     | 256       | 4               | 64    | 16     | 256       | 4               | 64    | 16     | 256       | 4                | 64  | 16     | 256       | 4               |  |  |
| 5   | 125   | 25     | 625       | 5               | 125   | 25     | 625       | 5               | 125   | 25     | 625       | 5                | 125   | 25     | 625       | 5               |  |  |
| 6   | 216   | 36     | 1296      | 6               | 216   | 36     | 1296      | 6               | 216   | 36     | 1296      | 6                | 216   | 36     | 1296      | 6               |  |  |
| 7   | 343   | 49     | 2401      | 7               | 343   | 49     | 2401      | 7               | 343   | 49     | 2401      | 7                | 343   | 49     | 2401      | 7               |  |  |
| 8   | 512   | 64     | 4096      | 8               | 512   | 64     | 4096      | 8               | 512   | 64     | 4096      | 8                | 512   | 64     | 4096      | 8               |  |  |
| 9   | 729   | 81     | 6561      | 9               | 729   | 81     | 6561      | 9               | 729   | 81     | 6561      | 9                | 729   | 81     | 6561      | 9               |  |  |
| 10  | 1000  | 100    | 10000     | 10              | 1000  | 100    | 10000     | 10              | 1000  | 100    | 10000     | 10               | 1000  | 100    | 10000     | 10              |  |  |
| 11  | 1331  | 121    | 14641     | 11              | 1331  | 121    | 14641     | 11              | 1331  | 121    | 14641     | 11               | 1331  | 121    | 14641     | 11              |  |  |
| 12  | 1728  | 144    | 20736     | 12              | 1728  | 144    | 20736     | 12              | 1728  | 144    | 20736     | 12               | 1728  | 144    | 20736     | 12              |  |  |
| 13  | 2197  | 169    | 28549     | 13              | 2197  | 169    | 28549     | 13              | 2197  | 169    | 28549     | 13               | 2197  | 169    | 28549     | 13              |  |  |
| Longitudinal Interval.                          |       |        |           |                 |       |        |           |                 |       |        |           |                  | Longitudinal Interval 16 ft.                    |        |           |                 |  |  |
|   |       |        |           |                 |       |        |           |                 |       |        |           |                  | 6797.6810                                       |        |           |                 |  |  |
|   |       |        |           |                 |       |        |           |                 |       |        |           |                  | 6797.4640                                       |        |           |                 |  |  |
|   |       |        |           |                 |       |        |           |                 |       |        |           |                  | 11259.110                                       |        |           |                 |  |  |
|   |       |        |           |                 |       |        |           |                 |       |        |           |                  | 3) 1690557.710                                  |        |           |                 |  |  |
|   |       |        |           |                 |       |        |           |                 |       |        |           |                  | 55879.080                                       |        |           |                 |  |  |
|   |       |        |           |                 |       |        |           |                 |       |        |           |                  | 8) 1557.56.100                                  |        |           |                 |  |  |
| Vol. of Displ. to 7718.51168578.105             |       |        |           |                 |       |        |           |                 |       |        |           |                  | Vol. of Displ. to 83118.94.17918.808            |        |           |                 |  |  |
| Metacentre above C. of Buoy. 20.563             |       |        |           |                 |       |        |           |                 |       |        |           |                  | Metac. above C. of Buoy. 6.727                  |        |           |                 |  |  |
| Functions { 311.4 x 1 = 311.4 x 0 = 0           |       |        |           |                 |       |        |           |                 |       |        |           |                  | Functions { 488.4 x 1 = 488.4 x 0 = 0           |        |           |                 |  |  |
| of Areas { 102.2 x 1 = 102.2 x 0 = 0            |       |        |           |                 |       |        |           |                 |       |        |           |                  | of Areas { 607.6 x 1 = 607.6 x 0 = 0            |        |           |                 |  |  |
| of Water { 70 x 1 = 70 x 0 = 0                  |       |        |           |                 |       |        |           |                 |       |        |           |                  | of Water { 412.8 x 1 = 412.8 x 0 = 0            |        |           |                 |  |  |
| planes { 70 x 1 = 70 x 0 = 0                    |       |        |           |                 |       |        |           |                 |       |        |           |                  | planes { 311.4 x 1 = 311.4 x 0 = 0              |        |           |                 |  |  |
| Function of vol. of Displ. to 2nd W.P. { 1000.4 |       |        |           |                 |       |        |           |                 |       |        |           |                  | Function of vol. of Displ. to 4th W.P. { 3044.8 |        |           |                 |  |  |
| Water-planes apart . . . 7.31                   |       |        |           |                 |       |        |           |                 |       |        |           |                  | Water-planes apart . . . 1.103                  |        |           |                 |  |  |
| C. of Buoy. below 2nd w. plane 1.7744           |       |        |           |                 |       |        |           |                 |       |        |           |                  | C. of Buoy. below 4th w. plane 6.727            |        |           |                 |  |  |

\* For example of curve see p. 168. † For Functions of areas see Displacement Paper, p. 153.

## PRELIMINARY TABLE FOR STABILITY AT 30° ANGLE OF HEEL.

| No. of Seps.    | Ordinates | Multiplicers | Functions of Ordinates | Squares of Ordinates | Multiplicers | Functions of Squares | Cubes of Ordinates | Multiplicers | Functions of Cubes |
|-----------------|-----------|--------------|------------------------|----------------------|--------------|----------------------|--------------------|--------------|--------------------|
| IMMERSED WEDGE. |           |              |                        |                      |              |                      |                    |              |                    |
| 1               | 8         | 1            | 4                      | 6                    | 1            | 5                    | 5                  | 1            | 5                  |
| 1½              | 8.1       | 2            | 16.2                   | 65.6                 | 2            | 131.2                | 531.4              | 2            | 1062.8             |
| 2               | 14.2      | 1            | 14.2                   | 201.6                | 1            | 201.6                | 2863.8             | 1            | 2863.8             |
| 2½              | 17.8      | 2            | 35.6                   | 316.8                | 2            | 633.6                | 5639.7             | 2            | 11279.4            |
| 3               | 20.5      | 1½           | 30.7                   | 420.2                | 1½           | 630.3                | 8615.1             | 1½           | 12922.7            |
| 4               | 20.4      | 4            | 81.6                   | 416.2                | 4            | 1664.8               | 8489.7             | 4            | 33958.8            |
| 5               | 20.2      | 2            | 40.4                   | 408.0                | 2            | 816.0                | 8242.2             | 2            | 16484.4            |
| 6               | 20.2      | 4            | 80.8                   | 408.0                | 4            | 1632.0               | 8242.2             | 4            | 32969.6            |
| 7               | 20.2      | 2            | 40.4                   | 408.0                | 2            | 816.0                | 8242.2             | 2            | 16484.4            |
| 8               | 20.2      | 4            | 80.8                   | 408.0                | 4            | 1632.0               | 8242.2             | 4            | 32969.6            |
| 9               | 20.2      | 1½           | 30.3                   | 408.0                | 1½           | 612.0                | 8242.2             | 1½           | 12363.6            |
| 9½              | 20.3      | 2            | 40.6                   | 412.0                | 2            | 824.0                | 8363.6             | 2            | 16727.2            |
| 10              | 18.8      | 1            | 18.8                   | 353.4                | 1            | 353.4                | 6644.7             | 1            | 6644.7             |
| 10½             | 15.8      | 2            | 31.6                   | 249.6                | 2            | 499.2                | 3944.8             | 2            | 7888.6             |
| 11              | 10.6      | 1            | 5.3                    | 112.4                | 1            | 56.2                 | 1191.0             | 1            | 596.5              |
|                 |           |              | 3)547.8                |                      |              | 3)10502.6            |                    |              | 3)204972.9         |
|                 |           |              | 182.4                  |                      |              | 3500.8               | Immersed           |              | 68324.9            |
|                 |           |              |                        |                      |              |                      | Emerged            |              | 58590.4            |
|                 |           |              |                        |                      |              |                      | Both wedges        |              | 126914.7           |
| EMERGED WEDGE.  |           |              |                        |                      |              |                      |                    |              |                    |
| 1               | 1.1       | 1            | 5                      | 1.2                  | 1            | 6                    | 1.3                | 1            | 7                  |
| 1½              | 6.5       | 2            | 13.0                   | 42.2                 | 2            | 84.4                 | 274.6              | 2            | 549.2              |
| 2               | 10.9      | 1            | 10.9                   | 118.8                | 1            | 118.8                | 1295.0             | 1            | 1295.0             |
| 2½              | 14.1      | 2            | 28.2                   | 198.8                | 2            | 397.6                | 2803.2             | 2            | 5606.4             |
| 3               | 16.9      | 1½           | 25.3                   | 285.6                | 1½           | 428.4                | 4826.8             | 1½           | 7240.2             |
| 4               | 20.0      | 4            | 80.0                   | 400.0                | 4            | 1600.0               | 8000.8             | 4            | 32003.2            |
| 5               | 21.2      | 2            | 42.4                   | 449.4                | 2            | 898.8                | 9528.1             | 2            | 19056.2            |
| 6               | 21.5      | 4            | 86.0                   | 462.2                | 4            | 1848.8               | 9938.4             | 4            | 39753.6            |
| 7               | 21.2      | 2            | 42.4                   | 449.4                | 2            | 898.8                | 9528.1             | 2            | 19056.2            |
| 8               | 20.1      | 4            | 80.4                   | 404.0                | 4            | 1616.0               | 8120.6             | 4            | 32482.4            |
| 9               | 17.5      | 1½           | 26.2                   | 306.2                | 1½           | 459.3                | 5359.4             | 1½           | 8039.1             |
| 9½              | 15.4      | 2            | 30.8                   | 237.1                | 2            | 474.2                | 3652.3             | 2            | 7304.6             |
| 10              | 12.5      | 1            | 12.5                   | 156.2                | 1            | 156.2                | 1953.1             | 1            | 1953.1             |
| 10½             | 8.9       | 2            | 17.8                   | 79.2                 | 2            | 158.4                | 705.0              | 2            | 1410.6             |
| 11              | 3.5       | 1            | 1.7                    | 12.2                 | 1            | 5.1                  | 42.8               | 1            | 21.4               |
|                 |           |              | 3)508.1                |                      |              | 3)9146.4             |                    |              | 3)175771.3         |
|                 |           |              | 169.8                  |                      |              | 3048.8               |                    |              | 58590.4            |

COMBINATION TABLE FOR STABILITY AT 30° ANGLE OF HEEL.

| IMMERSED WEDGE                 |                                   |              |                        | EMERGED WEDGE                     |              |                        |                                   | BOTH WEDGES        |                      |                  |                     |
|--------------------------------|-----------------------------------|--------------|------------------------|-----------------------------------|--------------|------------------------|-----------------------------------|--------------------|----------------------|------------------|---------------------|
| Functions of Ordinates         | Functions of Squares of Ordinates | Products     | Functions of Ordinates | Functions of Squares of Ordinates | Products     | Functions of Ordinates | Functions of Squares of Ordinates | Statical Stability | Products for Moments | Products of Heel | Dynamical Stability |
| 0°                             | 2015.4                            | 2015.4       | 169.3                  | 3015.4                            | 3015.4       | 111478.2               | 111478.2                          | 111478.2           | 111478.2             | 111478.2         | 111478.2            |
| 5°                             | 1802.9                            | 1802.9       | 150.3                  | 2878.3                            | 11906.2      | 112340.9               | 112340.9                          | 112340.9           | 112340.9             | 112340.9         | 112340.9            |
| 10°                            | 1590.4                            | 1590.4       | 139.3                  | 2711.1                            | 5048.2       | 105141.4               | 105141.4                          | 105141.4           | 105141.4             | 105141.4         | 105141.4            |
| 15°                            | 1377.9                            | 1377.9       | 128.3                  | 2543.9                            | 11906.2      | 98080.8                | 98080.8                           | 98080.8            | 98080.8              | 98080.8          | 98080.8             |
| 20°                            | 1165.4                            | 1165.4       | 117.3                  | 2376.7                            | 6972.0       | 90720.3                | 90720.3                           | 90720.3            | 90720.3              | 90720.3          | 90720.3             |
| 25°                            | 952.9                             | 952.9        | 106.3                  | 2209.5                            | 12758.5      | 83360.8                | 83360.8                           | 83360.8            | 83360.8              | 83360.8          | 83360.8             |
| 30°                            | 740.4                             | 740.4        | 95.3                   | 2042.3                            | 19274.0      | 76001.3                | 76001.3                           | 76001.3            | 76001.3              | 76001.3          | 76001.3             |
| Immersed Wedge                 | 60882.1                           | 60882.1      | 64146.6                | 3048.9                            | 3048.9       | 195914.7               | 195914.7                          | 195914.7           | 195914.7             | 195914.7         | 195914.7            |
| Emerged Wedge                  | 60882.1                           | 60882.1      | 64146.6                | 3048.9                            | 3048.9       | 195914.7               | 195914.7                          | 195914.7           | 195914.7             | 195914.7         | 195914.7            |
| Angular Interval               | 1°                                | 1°           | 1°                     | 1°                                | 1°           | 1°                     | 1°                                | 1°                 | 1°                   | 1°               | 1°                  |
| Longitudinal Interval          | 1000                              | 1000         | 1000                   | 1000                              | 1000         | 1000                   | 1000                              | 1000               | 1000                 | 1000             | 1000                |
| Excess of Immersed Wedge       | 1901.23                           | 1901.23      | 1901.23                | 1901.23                           | 1901.23      | 1901.23                | 1901.23                           | 1901.23            | 1901.23              | 1901.23          | 1901.23             |
| Appendage                      | 328.00                            | 328.00       | 328.00                 | 328.00                            | 328.00       | 328.00                 | 328.00                            | 328.00             | 328.00               | 328.00           | 328.00              |
| Area of Water-plane            | 7197.7257.22                      | 7197.7257.22 | 7197.7257.22           | 7197.7257.22                      | 7197.7257.22 | 7197.7257.22           | 7197.7257.22                      | 7197.7257.22       | 7197.7257.22         | 7197.7257.22     | 7197.7257.22        |
| Thickness of Layer             | 32                                | 32           | 32                     | 32                                | 32           | 32                     | 32                                | 32                 | 32                   | 32               | 32                  |
| Connecting Layer               | 32                                | 32           | 32                     | 32                                | 32           | 32                     | 32                                | 32                 | 32                   | 32               | 32                  |
| Moment for Statical Layer      | 2477.15                           | 2477.15      | 2477.15                | 2477.15                           | 2477.15      | 2477.15                | 2477.15                           | 2477.15            | 2477.15              | 2477.15          | 2477.15             |
| Moment for Dynamical Layer     | 2477.15                           | 2477.15      | 2477.15                | 2477.15                           | 2477.15      | 2477.15                | 2477.15                           | 2477.15            | 2477.15              | 2477.15          | 2477.15             |
| Angular Int.                   | 1°                                | 1°           | 1°                     | 1°                                | 1°           | 1°                     | 1°                                | 1°                 | 1°                   | 1°               | 1°                  |
| Longitudinal Int.              | 1000                              | 1000         | 1000                   | 1000                              | 1000         | 1000                   | 1000                              | 1000               | 1000                 | 1000             | 1000                |
| C. of Gravity above C. of Buoy | 8.78                              | 8.78         | 8.78                   | 8.78                              | 8.78         | 8.78                   | 8.78                              | 8.78               | 8.78                 | 8.78             | 8.78                |
| Vol. of Displacement           | 8767                              | 8767         | 8767                   | 8767                              | 8767         | 8767                   | 8767                              | 8767               | 8767                 | 8767             | 8767                |
| Displacement in tons           | 1171                              | 1171         | 1171                   | 1171                              | 1171         | 1171                   | 1171                              | 1171               | 1171                 | 1171             | 1171                |

## WAVES.

## SEA WAVES.

In the ordinary sea wave, or wave of oscillation, the form alone has a translatory motion, as the particles composing it revolve at a uniform rate in circular orbits, the radius of these orbits varying with the undisturbed depth, but remaining constant for particles in any subsurface or subsurface of equal pressure horizontal when undisturbed; the form of wave-surface thus formed being trochoidal (see fig. 140), as also the form of any subsurface (see fig. 141), the only difference being that while the diameter of the rolling circle of the subsurface remains the same as for the wave-surface, the length of its tracing arm diminishes in geometrical progression in going downwards.

*Note.*—For easy method of constructing trochoid see fig. 145, p. 187.

FIG. 140.

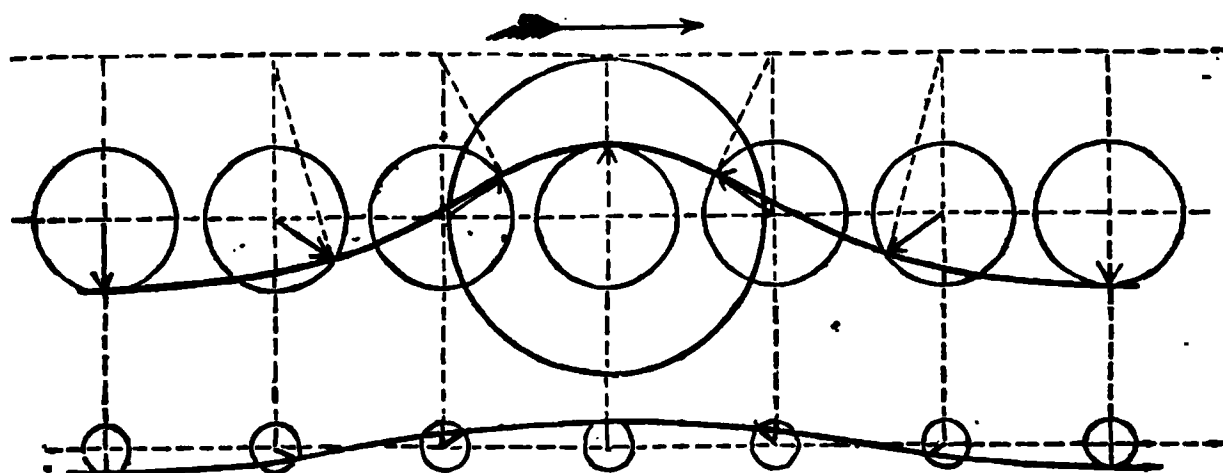
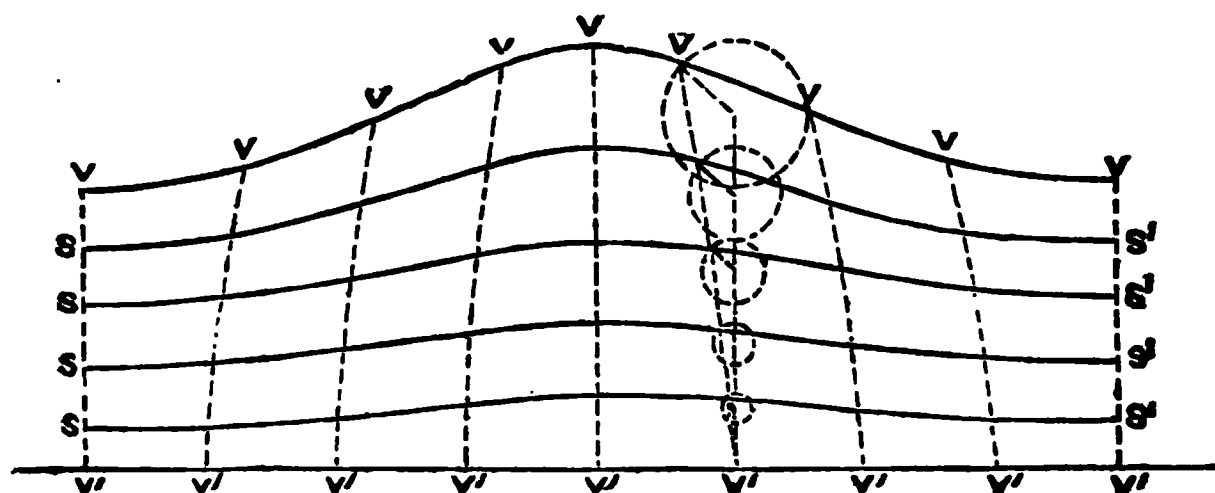


FIG. 141.



$v, v'$  are columns of water which are vertical in still water.  
 $s, s'$  are subsurfaces of equal pressure horizontal in still water.

## FORMULÆ.

$T$  = periodic time of wave in seconds.

$L$  = length of wave in feet.

$V$  = velocity of advance of wave in feet per second.

$V_1$  = velocity of advance of wave in knots per hour.

$V_2$  = velocity of advance of wave in miles per hour.

$R$  = radius of rolling circle in feet.

$r$  = radius of tracing arm for wave-surface in feet.

$g$  = accelerating force of gravity = 32.2 nearly.

$v$  = linear velocity of wave-surface particle in its orbit.

$s$  = sine of steepest slope of wave-surface.

$h$  = height of wave in feet.

$$T = 2\pi \sqrt{\frac{R}{g}} = \frac{2\pi r}{v} = \frac{L}{V}$$

$$R = \frac{T^2 g}{4\pi^2} = .8154 T^2 = \frac{L}{2\pi}$$

$$V = \sqrt{gR} = \frac{gT}{2\pi} = \sqrt{\frac{Lg}{2\pi}} = \frac{L}{T}$$

$$V_1 = \frac{V}{1.688}$$

$$V_2 = .6819V = 1.151V_1$$

$$L = 2\pi R = \frac{2\pi V^2}{g} = \frac{V^2}{5.1233} = V \times T$$

$$v = \frac{2\pi r}{T} = r \sqrt{\frac{g}{R}}$$

$$s = \frac{h}{2R} = \frac{h\pi}{L}$$

### RULES. (Rankine.)

1. *To find the ratio in which the orbits and velocities of the particles are diminished at a given depth below the wave-surface.*

**RULE.**—Divide the given depth by the equivalent pendulum which is equal to the radius of the rolling circle; the natural number answering to the quotient in a table of hyperbolic logarithms will be the reciprocal of the ratio required.

**Note.**—Approximately the orbits and velocities of the particles of water are diminished by *one-half* for each additional depth below the surface, equal to *one-ninth* of a wave-length.

**Example** { Depth in fractions of a wave-length  $0 \frac{1}{8} \frac{2}{8} \frac{3}{8} \frac{4}{8}, \&c.$   
 { Proportionate velocities and diameters  $1 \frac{1}{2} \frac{1}{4} \frac{1}{8} \frac{1}{16}, \&c.$

2. *To find how high the centre of the orbit of a given particle is above the level of that particle in still water.*

**RULE (a).**—Divide the square of the diameter of the orbit by eight times the equivalent pendulum of the waves.

**RULE (b).**—Divide the square of the velocity of the particle in feet per second by 64.4 for the height in feet.

3. *To find the mechanical energy of a layer of water agitated by wave-motion.*

**RULE.**—Multiply the weight of the layer by twice the height at which the centres of the orbits of the particles stand above the positions of those particles when in still water.

**Note.**—One half of this energy consists in motion and the other half in elevation.

4. *To find the mechanical energy of a mass of water of a given horizontal area and of unlimited depth agitated by waves.*

RULE.—Multiply the area by one-sixteenth part of the square of the height of the waves and by the heaviness of the fluid (64 lbs. per cubic foot for sea water).

5. *To find the energy of one wave-length of a layer of water of a given breadth and thickness.*

RULE.—Multiply together the breadth and thickness of the layer, the square of the diameter of the orbits of the particles in it, the heaviness of the fluid and the constant  $\frac{\pi}{2} = 1.5708$ .

TABLE OF THE PERIODS AND LENGTHS OF SEA WAVES.

| Velocity in<br>Knots per<br>Hour | Velocity in<br>Feet per<br>Second | Velocity in<br>Statute Miles<br>per Hour | Period in<br>Seconds | Equivalent<br>Pendulum in<br>Feet | Length in<br>Feet |
|----------------------------------|-----------------------------------|--|----------------------|-----------------------------------|-------------------|
| 1                                | 1.688                             | 1.15                                     | .33                  | .09                               | .56               |
| 2                                | 3.376                             | 2.30                                     | .66                  | .36                               | 2.25              |
| 3                                | 5.064                             | 3.45                                     | .98                  | .80                               | 5.06              |
| 4                                | 6.752                             | 4.60                                     | 1.31                 | 1.43                              | 9.00              |
| 5                                | 8.44                              | 5.75                                     | 1.64                 | 2.24                              | 14.05             |
| 6                                | 10.13                             | 6.91                                     | 1.97                 | 3.22                              | 20.2              |
| 7                                | 11.82                             | 8.06                                     | 2.30                 | 4.38                              | 27.5              |
| 8                                | 13.50                             | 9.21                                     | 2.63                 | 5.72                              | 36.0              |
| 9                                | 15.19                             | 10.36                                    | 2.96                 | 7.24                              | 45.5              |
| 10                               | 16.88                             | 11.51                                    | 3.29                 | 8.94                              | 56.2              |
| 11                               | 18.57                             | 12.66                                    | 3.32                 | 10.8                              | 68.0              |
| 12                               | 20.26                             | 13.81                                    | 3.65                 | 12.9                              | 80.9              |
| 13                               | 21.94                             | 14.96                                    | 4.27                 | 15.1                              | 95.0              |
| 14                               | 23.63                             | 16.11                                    | 4.60                 | 17.5                              | 110.1             |
| 15                               | 25.32                             | 17.26                                    | 4.93                 | 20.1                              | 126.4             |
| 16                               | 27.01                             | 18.42                                    | 5.26                 | 22.9                              | 143.8             |
| 17                               | 28.70                             | 19.57                                    | 5.59                 | 25.8                              | 162.3             |
| 18                               | 30.38                             | 20.72                                    | 5.92                 | 29.0                              | 182.0             |
| 19                               | 32.07                             | 21.87                                    | 6.25                 | 32.3                              | 202.8             |
| 20                               | 33.76                             | 23.02                                    | 6.58                 | 35.8                              | 224.7             |
| 21                               | 35.45                             | 24.17                                    | 6.91                 | 39.4                              | 247.8             |
| 22                               | 37.14                             | 25.32                                    | 7.24                 | 43.3                              | 272.0             |
| 23                               | 38.82                             | 26.47                                    | 7.57                 | 47.3                              | 297.3             |
| 24                               | 40.51                             | 27.62                                    | 7.90                 | 51.5                              | 323.6             |
| 25                               | 42.20                             | 28.77                                    | 8.23                 | 55.9                              | 351.2             |
| 26                               | 43.89                             | 29.93                                    | 8.56                 | 60.4                              | 379.8             |
| 27                               | 45.58                             | 31.08                                    | 8.89                 | 65.2                              | 409.6             |
| 28                               | 47.26                             | 32.23                                    | 9.21                 | 70.1                              | 440.5             |
| 29                               | 48.95                             | 33.38                                    | 9.54                 | 75.2                              | 472.5             |
| 30                               | 50.64                             | 34.53                                    | 9.87                 | 80.5                              | 505.7             |

## SHALLOW-WATER WAVES.

In shallow water of uniform depth the orbit of each particle is an oval, the orbits becoming more flattened the nearer the particles are to the bottom.

As an approximation water may be taken as *shallow* when the depth is between  $\frac{5}{12}$  and  $\frac{1}{38}$  of a wave-length.

$l$  = length of shallow-water wave in feet.

$L$  = length of  $l$  computed as if for deep water.

$v$  = velocity of advance of shallow-water wave in feet.

$V$  = velocity of advance of wave computed as if for deep water.

$d$  = depth of water = height of surface particles from bottom.

$b$  = breadth of surface-particles orbits.

$h$  = height of surface-particles orbits.

$t$  = periodic time of wave in seconds.

$x$  = natural number corresponding to hyperbol. log. of  $\frac{2\pi d}{l}$ .

$g$  = accelerating force of gravity = 32.2.

$$\left. \begin{aligned} v &= \sqrt{\frac{gh}{2\pi b}} = V \sqrt{\frac{h}{b}} = \frac{l}{t} \\ t &= \sqrt{\frac{2\pi lb}{gh}} = \frac{l}{v} \end{aligned} \right\} \text{where } d \text{ exceeds } \frac{1}{38} \text{ of } l.$$

$$v = \sqrt{gd} \quad \text{where } d \text{ is less than } \frac{1}{38} \text{ of } l.$$

$$b = h \left( \frac{x + \frac{1}{x}}{x - \frac{1}{x}} \right) \quad h = b \left( \frac{x - \frac{1}{x}}{x + \frac{1}{x}} \right) \quad \frac{h}{b} = \frac{x - \frac{1}{x}}{x + \frac{1}{x}} = \frac{L}{l}$$

$$l = \frac{Lb}{h} \left\{ \text{where } d \text{ exceeds } \frac{1}{38} \text{ of } l. \right.$$

$$l = \frac{L + 2\pi d}{2} \left\{ \text{where } d \text{ is less than } \frac{1}{38} \text{ of } l. \right.$$

TABLE OF THE RATIOS OF WAVES FOR SHALLOW WATER TO THE CORRESPONDING QUANTITIES FOR DEEP WATER.

| Depth of Water<br>from Centres of<br>Orbits in Fractions<br>of Wave's Length | RATIOS                               |  |                                      | Depth of Water<br>from Centres of<br>Orbits in Fractions<br>of Wave's Length | RATIOS                               |  |                                      |
|--|--------------------------------------|--|--------------------------------------|--|--------------------------------------|--|--------------------------------------|
|  | Velocity<br>for a<br>given<br>Length | Length<br>and Velo-<br>city for a<br>given<br>Period | Length<br>for a<br>given<br>Velocity |  | Velocity<br>for a<br>given<br>Length | Length<br>and Velo-<br>city for a<br>given<br>Period | Length<br>for a<br>given<br>Velocity |
| $\frac{1}{38}$   | .417                                 | .174   | 5.76                                 | $\frac{2}{38}$   | .884                                 | .781   | 1.28                                 |
| $\frac{2}{38}$   | .579                                 | .336   | 2.98                                 | $\frac{3}{38}$   | .940                                 | .884   | 1.13                                 |
| $\frac{3}{38}$   | .693                                 | .481   | 2.08                                 | $\frac{4}{38}$   | .969                                 | .939   | 1.06                                 |
| $\frac{4}{38}$   | .776                                 | .603   | 1.66                                 | $\frac{5}{38}$   | .985                                 | .970   | 1.03                                 |
| $\frac{5}{38}$   | .838                                 | .703   | 1.42                                 | $\frac{6}{38}$   | .995                                 | .989   | 1.01                                 |



## ROLLING.

## ISOCHRONOUS ROLLING IN STILL WATER.

$\tau$  = periodic time of unresisted oscillation, or double roll, in seconds.

$\tau_1$  = periodic time of resisted double roll in seconds.

$M$  = height of metacentre above centre of gravity in feet.

$I$  = transverse moment of inertia of weight of ship.

$n$  = number of oscillations a vessel actually makes in time  $t$  in seconds.

$\theta$  = greatest angle of heel at commencement of time  $t$ .

$\theta_1$  = diminished angle of heel at end of time  $t$ .

$$c = \left( \frac{\text{hyp log } \theta - \text{hyp log } \theta'}{t} \right) = \left( \frac{\log \theta - \log \theta'}{.4343t} \right) = \frac{gl}{2r^2}.$$

$h$  = height of equivalent pendulum in feet for unresisted rolling. For resisted rolling substitute  $\tau_1$  for  $\tau$ .

$r$  = transverse radius of gyration in feet.

$m$  = moment of righting couple at angle  $\theta = M \times D \times \theta$ , where  $\theta$  is expressed in circular measure.

$D$  = displacement in tons, i.e. weight of the ship.

$l$  = length of leverage of keel resistance in feet.

$g$  = accelerating force of gravity = 32.2 nearly.

$$\tau = \sqrt{\frac{4\pi^2 r^2}{gM}} = \frac{2\pi r}{\sqrt{gM}} = \sqrt{\frac{r^2}{.8154M}} = \sqrt{\frac{4\pi^2 h}{g}} = \sqrt{\frac{h}{.815}} = \frac{\tau_1^2}{1 + \frac{c^2 \tau_1^2}{39.48}}$$

$$\tau_1 = \frac{t}{n} = \frac{2\pi}{\sqrt{\left\{ \frac{gM}{r^2} - \frac{g^2 l^2}{4r^4} \right\}}} = \frac{\sqrt{\frac{r^2}{.815M}}}{\sqrt{\left( 1 - \frac{gl^2}{4Mr^2} \right)}}$$

$$r^2 = \frac{gM\tau^2}{4\pi^2} = .815M\tau^2 = \frac{gM}{\frac{4\pi^2}{\tau_1^2} + c^2} = \frac{.815M\tau_1^2}{1 + \frac{c^2 \tau_1^2}{39.48}}$$

$$h = \frac{r^2}{M} = \frac{g\tau^2}{4\pi^2} = .815\tau^2 = \frac{m}{I \times \theta}$$

$$l = \frac{2cr^2}{g} = \frac{cr^2}{16.1} = \frac{2Mc}{\frac{4\pi^2}{\tau_1^2} + c^2}$$

*Note.*—The equivalent pendulum is one whose time of revolution is the same with the period of oscillation, or double roll.



## ISOCRONOUS ROLLING.

*In a true isochronous rolling ship her righting moment at any angle of heel is exactly proportional to the angle of disturbance, and her metacentric evolute is the involute of a circle described about the centre of gravity and through the metacentre; and consequently the metacentric involute is the volute of the volute of that circle.*

$M$  = height of metacentre above centre of gravity.

$m$  = height of metacentre above centre of buoyancy.

$m'$  = radius of curvature of metacentric involute when the angle of heel is  $\theta$  (in circular measure).

$y$  = half-breadth of upright water-section.

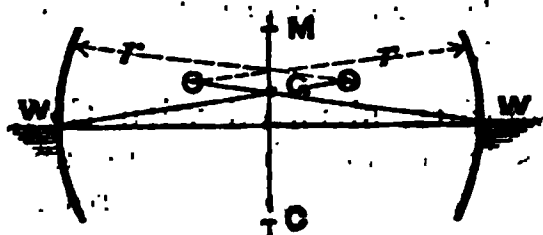
$y'$  = half-breadth of inclined water-section for the angle of heel  $\theta$ .

$$m' = m + \frac{M\theta^2}{2}$$

$$y' = y \left( 1 + \frac{M\theta^2}{2m} \right)^{\frac{1}{3}}.$$

*To approximate to the form of cross section between wind and water of a true isochronous rolling ship.*

FIG. 143.



In fig. 143 let  $M$  be the metacentre,  $G$  the centre of gravity,  $WW$  the upright water-plane,  $C$  the centre of buoyancy.

Draw the two lines  $W, G$ , and produce them beyond  $G$  to  $\odot$ , making  $W\odot = WG \frac{GM}{3CM}$ ; then the two

points  $\odot$  will be the centres of curvature for the circular arcs through the points  $W, W'$ .

$d$  = height of  $G$  above  $WW$ .

$r = W\odot$ .

$$r = \sqrt{y^2 + d^2} \left( 1 + \frac{M}{3m} \right).$$

*Note.*—The same notation is used as in the foregoing formula.

## PERIOD OF DIPPING.

$D$  = volume of displacement in cubic feet.

$A$  = area of load water-plane in square feet.

$\tau$  = periodic time of a complete dipping oscillation in seconds.

$h$  = height of equivalent pendulum in feet.

$g$  = accelerating force of gravity = 32.2 nearly.

$$\tau = 2\pi \sqrt{\frac{D}{Ag}} = \sqrt{\frac{h4\pi^2}{g}} = \sqrt{\frac{h}{3154}}.$$

## ROLLING AMONG WAVES.

*General Conclusions. (Rankine.)*

1. The stability of a ship tends to keep her upright to the effective wave-surface—that is, the subsurface of the wave which, in an ordinary vessel, may generally be taken as traversing her centre of buoyancy.

2. The permanent rolling of a ship of very great stability and little keel resistance, is governed by the motion of the effective wave-surface, so that she will roll *with the waves*, or like a raft.

3. When the period of unresisted rolling is to the wave period as  $\sqrt{2} : 1$ , the permanent rolling is wholly governed by the motion of the originally vertical columns of water; so that she will roll *against the waves*, like a board of no stability floating edgewise.

*Note.*—In the preceding cases, the vessel is upright when the trough or crest of a wave passes her, and her greatest angle of heel is equal to the steepest slope of the effective wave-surface.

4. When the period of a ship's unresisted rolling is less than the above value, her upright positions occur *before* the arrival of the troughs and crests of the waves, and her greatest angle of heel is *greater* than the steepest slope of the effective wave-surface.

5. When the period of a ship's unresisted rolling is equal to that of the waves, the greatest angle of permanent rolling occurs, and it exceeds the slope of the waves in a proportion which is the greater the less the keel resistance, and which becomes infinite when the keel resistance vanishes.

6. When the period of unresisted rolling of a vessel exceeds that of the waves in a greater ratio than that of  $\sqrt{2} : 1$ , her upright positions occur *after* the arrival of the troughs and crests of the waves, and her angle of heel is *less* than the greatest slope of the waves.

7. The most unfavourable proportions for the periodic time of free rolling to that of forced or passive rolling being those which lie near or between equality and  $\sqrt{2} : 1$ .

8. A period of free rolling much less than that of passive rolling gives great stiffness; and a period of free rolling exceeding  $\sqrt{2}$  times that of passive rolling is favourable to steadiness, provided that this lengthened period be produced by the inertia of the ship and not by insufficient statical stability.

| TABLE GIVING THE PERIODS OF OSCILLATION OF SHIPS. |                      |                         |                           |             |                      |                         |                           |
|---|----------------------|-------------------------|---------------------------|-------------|----------------------|-------------------------|---------------------------|
| ENGLISH NAVY                                      |                      |                         |                           | FRENCH NAVY |                      |                         |                           |
| Name  | Oscilla.<br>per Min. | Mean Roll<br>in Degrees | Height of<br>G.M. in Feet | Name        | Oscilla.<br>per Min. | Mean Roll<br>in Degrees | Height of<br>G.M. in Feet |
| Northumberland                                    | 4.0                  | 7.0                     | 1.99                      | Solférino   | 9.75                 | 17.14                   | 4.5                       |
| Agincourt   | 7.8                  | 7.5                     | 1.99                      | Magenta     | 10.0                 | 18.00                   | 5.05                      |
| Monarch   | 6.0                  | 5.0                     | 2.37                      | Napoléon    | 10.5                 | 18.56                   | 4.92                      |
| Inconstant  | 6.0                  | 4.0                     | 2.8                       | Couronne    | 12.0                 | 18.84                   | 5.57                      |
| Captain   | 7.0                  | 3.7                     | 2.60                      | Tourville   | 10.75                | 20.28                   | 5.31                      |
| Hercules  | 8.0                  | 4.5                     | 2.69                      | Invincible  | 12.0                 | 20.73                   | 6.36                      |
| Warrior   | 8.0                  | 16.0                    | 4.68                      | Normandie   | 12.5                 | 21.92                   | 6.59                      |
| Prince Consort                                    | 11.25                | 11.75                   | 6.01                      | Talisman    | 15.0                 | —                       | —                         |

## PROPULSION OF VESSELS.

## WAVE WATER-LINES.

The entrance of a pure wave water-line is a curve of versed sines, and the run trochoidal, the length of entrance being in proportion to the run as 8 : 2, and for a given speed there should also be a fixed proportion between that speed and the length of entrance and run, which can be obtained from the following table or from the following formulæ.

$V$  = velocity of ship in statute miles per hour.

$E$  = length of entrance in feet.

$$E = .42V^2.$$

$R$  = length of run in feet.

$$R = .3V^2.$$

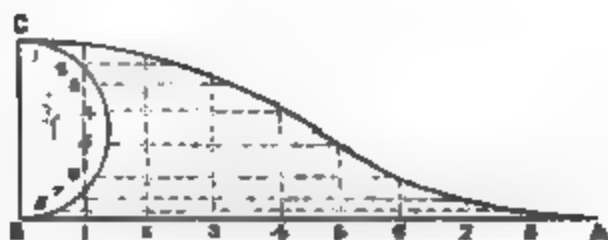
| TABLE GIVING THE LENGTH AND ENTRANCE OF RUN OF<br>WAVE WATER-LINES FOR A GIVEN SPEED. |                                  |                             |                                       |                                  |                             |
|---|----------------------------------|-----------------------------|---------------------------------------|----------------------------------|-----------------------------|
| Speed in<br>Statute Miles<br>per Hour   | Length of<br>Entrance<br>in Feet | Length of<br>Run in<br>Feet | Speed in<br>Statute Miles<br>per Hour | Length of<br>Entrance<br>in Feet | Length of<br>Run in<br>Feet |
| 1   | .42                              | .3                          | 11                                    | 50.82                            | 43.2                        |
| 2   | 1.68                             | 1.2                         | 12                                    | 60.48                            | 50.7                        |
| 3   | 3.78                             | 2.7                         | 13                                    | 70.98                            | 58.8                        |
| 4   | 6.72                             | 4.8                         | 14                                    | 82.32                            | 67.5                        |
| 5   | 10.50                            | 7.5                         | 15                                    | 94.50                            | 76.8                        |
| 6   | 15.12                            | 10.8                        | 16                                    | 107.52                           | 86.7                        |
| 7   | 20.58                            | 14.7                        | 17                                    | 121.38                           | 97.2                        |
| 8   | 26.88                            | 19.2                        | 18                                    | 136.08                           | 108.3                       |
| 9   | 34.02                            | 24.3                        | 19                                    | 151.62                           | 120.0                       |
| 10  | 42.10                            | 30.0                        | 20                                    | 168.00                           |                             |

*Note.*—There may be any length of parallel middle body.

## METHOD OF CONSTRUCTION OF ENTRANCE OF WAVE-LINE.

Let  $AB$  = length of entrance, and  $BC$  the diameter of semicircle = the half-breadth; divide the length  $AB$  into the same number of equal parts as the circumference of the semicircle; then through the points of division of the semicircle draw lines parallel to  $AB$  and cutting other lines drawn through the points of division of  $AB$  and perpendicular to it: the intersection of the horizontal with the respective vertical lines will give points in the curve.

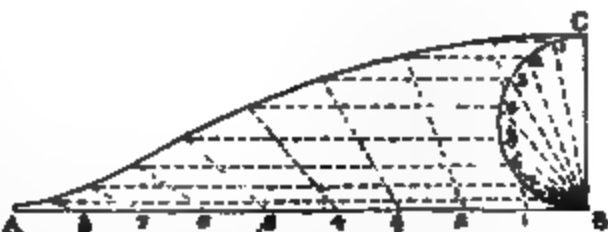
FIG. 144.



## METHOD OF CONSTRUCTION OF RUN OF WAVE-LINE.

Divide the length of the run  $AB$  and the semicircle on the half-breadth  $BC$  into the same number of equal parts; in the semicircle draw the chords  $B8, B7, B6$ , &c., and through the points of division on  $AB$  draw lines parallel to them: then the points of intersection of those lines with the respective lines drawn through the points of division of the semicircle, and parallel to the base  $AB$ , will be points in the curve.

FIG. 145.

PROPULSION OF VESSELS. (*Rankine*.)

$G$  = length of mean immersed girth in feet.

$C$  = coefficient of augmentation.

$S$  = area of augmented surface in square feet.

$k$  = coefficient of propulsion.

[skin.

= 20000 for a ship designed with waves-lines and iron

= 21800 for a ship designed with waves-lines and copper-sheathed.

$V$  = velocity of ship in knots per hour.

[lines.

$M$  = mean of squares of sines of greatest obliquity of water-

$M_1$  = mean of fourth powers of sines of greatest obliquity of water-lines.

$H$  = horse-power required to propel vessel at  $V$  speed.

$$C = 1 + 4M + M_1$$

$$k = \frac{8V}{H}$$

$$V = \sqrt[3]{\frac{Hk}{S}}$$

$$H = \frac{8V^3}{k}$$

TABLE SHOWING METHOD OF COMPUTING THE SPEED OF  
A VESSEL WITH A GIVEN INDICATED HORSE-POWER.

| Coefficient of Augmentation   |                   |                  |                    | Augmented Surface         |                   |               |          |
|---|-------------------|------------------|--------------------|---------------------------|-------------------|---------------|----------|
| Water-lines   | Sine of Obliquity | Squares of Sines | 4th Power of Sines | No. of Ordins.            | Half-girths. Feet | Simps. Mults. | Products |
| L. w. line  | ·370              | ·1369            | ·01874             | 1                         | 21·0              | 1             | 21·0     |
| 2nd w. line   | ·315              | ·0992            | ·00984             | 2                         | 27·2              | 4             | 108·8    |
| 3rd w. line   | ·290              | ·0841            | ·00707             | 3                         | 30·8              | 2             | 61·6     |
| 4th w. line   | ·265              | ·0702            | ·00492             | 4                         | 34·6              | 4             | 138·4    |
| 5th w. line   | ·235              | ·0552            | ·00304             | 5                         | 38·8              | 2             | 77·6     |
| 6th w. line   | ·165              | ·0272            | ·00074             | 6                         | 41·5              | 4             | 166·0    |
| Keel  | ·000              | ·0000            | ·00000             | 7                         | 42·6              | 2             | 85·2     |
|   |                   |                  |                    | 8                         | 44·0              | 4             | 176·0    |
|   |                   |                  |                    | 9                         | 44·0              | 2             | 88·0     |
|   |                   |                  |                    | 10                        | 44·0              | 4             | 176·0    |
|   |                   |                  |                    | 11                        | 43·3              | 2             | 86·6     |
|   |                   |                  |                    | 12                        | 42·1              | 4             | 168·4    |
|   |                   |                  |                    | 13                        | 40·3              | 2             | 80·6     |
|   |                   |                  |                    | 14                        | 38·1              | 4             | 152·4    |
|   |                   |                  |                    | 15                        | 36·0              | 2             | 72·0     |
|   |                   |                  |                    | 16                        | 35·0              | 4             | 140·0    |
|   |                   |                  |                    | 17                        | 32·0              | 1             | 32·0     |
| Means   |                   |                  |                    |                           |                   |               |          |
|   |                   | ·0674            | ·00583             |                           |                   |               |          |
| $1 + (4 \times \cdot 0674) + \cdot 00583 = 1\cdot 275$<br>= coefficient of augmentation |                   |                  |                    |                           |                   |               |          |
| Speed in Knots  |                   |                  |                    |                           |                   |               |          |
| Indicated horse-power   |                   | 5471             |                    |                           |                   |               |          |
| Coefficient of propulsion   |                   | 20000            |                    |                           |                   |               |          |
| Augment. surface  |                   | 36979            |                    |                           |                   |               |          |
| Cube of probable speed  |                   | 2·959            |                    |                           |                   |               |          |
| Probable speed in knots   |                   | 14·356           |                    |                           |                   |               |          |
| Indicated Horse-power   |                   |                  |                    |                           |                   |               |          |
| Cube of speed in knots  |                   | 2959             |                    |                           |                   |               |          |
| Augmented surface   |                   | 36979            |                    |                           |                   |               |          |
| Coeff. of prop.   |                   | 20000            |                    |                           |                   |               |          |
| Indicated horse-power   |                   | 5471             |                    |                           |                   |               |          |
|   |                   | 0·430            |                    |                           |                   |               |          |
|   |                   |                  |                    | Divide by 8) 1830·6       |                   |               |          |
|   |                   |                  |                    | Half No. of Int. 8) 610·2 |                   |               |          |
| Mean girth  |                   | 76·3             |                    |                           |                   |               |          |
| Length of ship  |                   | 380              |                    |                           |                   |               |          |
| Product   |                   | 28994            |                    |                           |                   |               |          |
| Coeff. of aug.  |                   | 1·275            |                    |                           |                   |               |          |
| Augment. surface  |                   | 36979            |                    |                           |                   |               |          |
| in square feet  |                   |                  |                    |                           |                   |               |          |

## PROPULSION OF VESSELS. (*Scott Russell*).

$A =$  area of immersed part of midship section in square feet.

$c$  = coefficient of form of water-lines (see table, p. 189).

**H** = head resistance to midship section in lbs.

$W$  = area of wet surface in square feet,

$k$  = coefficient of skin resistance (see table, p. 189).

$s$  = total of skin resistance in lbs.

$v$  = velocity of ship in miles per hour,

$v$  = velocity of slip in miles per hour.

**P**=horse-power required to propel vessel at **v** speed.

$$H = 2.852346 C A V^2 \quad S = k W V^2 \quad P = \frac{.0098684 (V + v) (H + S)}{330v}$$

*Note.*—These formulæ must not be trusted implicitly for high speeds.

TABLE OF COEFFICIENTS OF RESISTANCE FOR VARIOUS KINDS OF SKIN.

| Kind of Skin        | Coeff. | Kind of Skin      | Coeff. | Kind of Skin    | Coeff. |
|---------------------|--------|-------------------|--------|-----------------|--------|
| Clean copper sheets | ·007   | Common iron skin  | ·014   | Moderately foul | ·019   |
| Smooth paint        | ·010   | Smooth-sawn plank | ·016   | Barnacled       | ·055   |

TABLE OF COEFFICIENTS OF FORM FOR VARIOUS KINDS OF WATER-LINES.

| Kind of Water-line            | Coeff. | Kind of Water-line            | Coeff. | Kind of Water-line | Coeff. |
|-------------------------------|--------|-------------------------------|--------|--------------------|--------|
| Wedge $\angle 44^\circ$       | ·57    | Convex arcs $\angle 25^\circ$ | ·31    | Wave form 7 to 1   | ·056   |
| Wedge $\angle 35^\circ$       | ·51    | Convex arcs $\angle 15^\circ$ | ·20    | Wave form 8 to 1   | ·043   |
| Wedge $\angle 18^\circ$       | ·38    | Wave form 5 to 1              | ·15    | Wave form 9 to 1   | ·034   |
| Convex arcs $\angle 35^\circ$ | ·64    | Wave form 6 to 1              | ·077   | Wave form 10 to 1  | ·028   |

TABLE OF RESISTANCE IN LBS. TO ONE SQUARE FOOT OF FLAT-FRONTED VESSEL, AND HORSE-POWER REQUIRED TO PROPEL IT AT VARIOUS SPEEDS.

| Ft. per sec. | Resistance | Horse-power | Miles an Hour | Resistance | Horse-power | Knots an Hour | Resistance | Horse-power |
|--------------|------------|-------------|---------------|------------|-------------|---------------|------------|-------------|
| 1            | 1          | 0·00182     | 1             | 2·15111    | 0·00574     | 1             | 2·85235    | 0·00876     |
| 2            | 4          | 0·01455     | 2             | 8·60444    | 0·04589     | 2             | 11·40938   | 0·07007     |
| 3            | 9          | 0·04909     | 3             | 19·36000   | 0·15488     | 3             | 25·67111   | 0·23649     |
| 4            | 16         | 0·11636     | 4             | 34·41778   | 0·36712     | 4             | 45·63754   | 0·56056     |
| 5            | 25         | 0·22727     | 5             | 53·77778   | 0·71704     | 5             | 71·30865   | 1·09484     |
| 6            | 36         | 0·39273     | 6             | 77·41000   | 1·23904     | 6             | 102·68445  | 1·89188     |
| 7            | 49         | 0·62364     | 7             | 105·40444  | 1·96755     | 7             | 139·76495  | 3·00424     |
| 8            | 64         | 0·93091     | 8             | 137·67111  | 2·93698     | 8             | 182·55014  | 4·48446     |
| 9            | 81         | 1·32545     | 9             | 174·24000  | 4·18176     | 9             | 231·04003  | 6·38511     |
| 10           | 100        | 1·81818     | 10            | 215·11111  | 5·73629     | 10            | 285·23460  | 8·75872     |
| 11           | 121        | 2·42000     | 11            | 260·28444  | 7·63463     | 11            | 345·13387  | 11·65786    |
| 12           | 144        | 3·14182     | 12            | 309·76000  | 9·91231     | 12            | 410·73780  | 15·13506    |
| 13           | 169        | 3·99455     | 13            | 363·53778  | 12·60263    | 13            | 482·04647  | 19·24290    |
| 14           | 196        | 4·98909     | 14            | 421·61778  | 15·74038    | 14            | 559·05980  | 24·03392    |
| 15           | 225        | 6·13636     | 15            | 484·00000  | 19·35998    | 15            | 641·71785  | 29·56068    |



# 100 COEFFICIENTS OF PERFORMANCE OF STEAM VESSELS.

## SPEED FORMULA AS GENERALLY USED FOR STEAM VESSELS.

$v$  = velocity in knots per hour.       $V$  = any other velocity in knots per hour.  
 $H$  = indicated horse-power for  $v$  speed.       $H$  = indicated horse-power for  $V$  speed.  
 $D$  = displacement in tons.       $X$  = area of midship section in square feet.  
 $L$  = length of vessel in feet.       $\lambda$  = displacement coefficient of performance.

$$v = \sqrt{\frac{H \times L}{X}} \quad H = \frac{v^2 \times X}{L} \quad \lambda = \frac{v^2 \times X}{H} \quad v = \sqrt{\frac{H}{\lambda}}$$

$$V = \sqrt{\frac{H \times L}{D}} \quad H = \frac{V^2 \times D}{L} \quad \lambda = \frac{V^2 \times D}{H} \quad \lambda = \left(\frac{V}{v}\right)^2 \lambda$$

NOTE.—These formula may be taken as sufficiently accurate up to 15 knots speed, when from 15 knots and upwards  $V$  and even  $V$  may be substituted as high speeds for  $v$ .

In the following tables let—  
 $v$  = speed in knots per hour.  
 $D$  = displacement in tons.  
 $L$  = length of vessel in feet.

$V$  = velocity in knots per hour.  
 $H$  = indicated horse-power.  
 $X$  = area of midship section in square feet.  
 $\lambda$  = breadth of vessel in feet.

TABLE OF COEFFICIENTS OF PERFORMANCE, ETC., OF SOME OF HER MAJESTY'S SCREW VESSELS.

| Name of Vessel | L   | $\frac{L}{D}$ | X    | D    | H      | V      | $\lambda$ | $\frac{H}{V^2}$ | $\frac{H}{D}$ | $\frac{V^2 \times X}{H}$ | $\frac{V^2 \times D}{H}$ |
|----------------|-----|---------------|------|------|--------|--------|-----------|-----------------|---------------|--------------------------|--------------------------|
| Agincourt      | 400 | 0.73          | 105  | 9671 | 9667   | 15.433 | Neg       | 5.79            | 15.79         | 431.3                    | 332.9                    |
| "              | 400 | 0.73          | 105  | 9130 | 9671   | 15.787 | Neg       | 4.70            | 15.80         | 536.1                    | 330.9                    |
| "              | 400 | 0.73          | 105  | 8152 | 9667   | 16.966 | Neg       | 2.51            | 16.85         | 530.4                    | 314.6                    |
| Minotaur       | 400 | 0.69          | 115  | 9667 | 9226   | 14.779 | Neg       | 5.47            | 14.67         | 590.6                    | 317.7                    |
| "              | 400 | 0.69          | 115  | 9667 | 9165   | 15.367 | Neg       | 3.90            | 14.10         | 637.7                    | 304.7                    |
| "              | 400 | 0.69          | 115  | 1140 | 9457   | 17.647 | Neg       | 3.00            | 7.44          | 473.9                    | 320.1                    |
| Amphib         | 300 | 0.53          | 135  | 7465 | 9455   | 14.354 | Neg       | 4.45            | 13.77         | 656.5                    | 300.1                    |
| "              | 300 | 0.53          | 135  | 6962 | 9455   | 15.169 | Neg       | 3.73            | 13.45         | 636.4                    | 310.3                    |
| "              | 300 | 0.53          | 135  | 6447 | 9455   | 16.349 | Neg       | 2.85            | 12.15         | 713.7                    | 304.9                    |
| "              | 300 | 0.53          | 135  | 5926 | 9457   | 17.172 | Neg       | 2.08            | 11.96         | 690.9                    | 320.9                    |
| Warrior        | 300 | 0.55          | 1319 | 9657 | 9457   | 16.336 | Neg       | 4.49            | 12.77         | 656.1                    | 321.5                    |
| "              | 300 | 0.55          | 1319 | 9714 | 9457   | 16.376 | Neg       | 4.11            | 12.76         | 669.7                    | 321.5                    |
| "              | 300 | 0.55          | 1319 | 9653 | 9457   | 16.514 | Neg       | 3.25            | 12.70         | 707.1                    | 320.3                    |
| "              | 300 | 0.55          | 1319 | 9652 | 9456   | 17.141 | Neg       | 2.10            | 12.63         | 754.4                    | 320.3                    |
| "              | 300 | 0.55          | 1319 | 9469 | 9777   | 18.115 | Neg       | 1.33            | 12.31         | 810.6                    | 320.3                    |
| Exeter         | 300 | 0.73          | 814  | 9469 | 9461   | 11.533 | Neg       | 8.06            | 6.30          | 567.5                    | 300.0                    |
| "              | 300 | 0.73          | 814  | 9100 | 9461   | 12.007 | Neg       | 5.96            | 5.30          | 555.4                    | 300.0                    |
| Strap          | 300 | 0.73          | 776  | 9600 | 9615   | 14.006 | Neg       | 5.07            | 12.12         | 564.6                    | 320.1                    |
| "              | 300 | 0.73          | 776  | 9610 | 9615   | 14.176 | Neg       | 4.60            | 11.67         | 591.5                    | 300.4                    |
| "              | 300 | 0.73          | 776  | 9600 | 9617   | 15.556 | Neg       | 3.06            | 9.96          | 560.1                    | 300.0                    |
| Immaculate     | 327 | 0.71          | 909  | 5136 | 7361   | 6.513  | Neg       | 11.94           | 24.45         | 55.46                    | 140.6                    |
| "              | 327 | 0.71          | 909  | 5136 | 7361   | 6.513  | Neg       | 8.99            | 11.57         | 422.45                   | 320.3                    |
| Sultan         | 325 | 0.85          | 1329 | 9714 | 9671   | 4.134  | Neg       | 26.84           | 30.38         | 411.79                   | 130.6                    |
| Captain        | 320 | 0.85          | 1111 | 7622 | 9667   | 4.251  | Neg       | 5.09            | 15.11         | 306.4                    | 140.6                    |
| "              | 320 | 0.85          | 1111 | 7622 | 9667   | 4.251  | Neg       | 3.47            | 14.49         | 646.0                    | 315.7                    |
| Malvern        | 300 | 0.59          | 1065 | 6379 | 9466   | 4.237  | Neg       | 3.70            | 17.26         | 511.1                    | 140.6                    |
| "              | 300 | 0.59          | 1065 | 5700 | 9466   | 13.646 | Neg       | 4.63            | 14.75         | 540.2                    | 170.2                    |
| "              | 300 | 0.59          | 1065 | 6379 | 9119   | 12.101 | Neg       | 5.93            | 9.66          | 606.3                    | 190.3                    |
| "              | 300 | 0.59          | 1114 | 6664 | 9664   | 11.760 | Neg       | 5.23            | 8.72          | 631.3                    | 190.7                    |
| Orestes        | 300 | 1.67          | 444  | 3400 | 1323   | 10.661 | Neg       | 1.63            | 7.05          | 5.75                     | 370.7                    |
| "              | 300 | 1.67          | 741  | 4766 | 96     | 9.555  | Neg       | 1.75            | 4.17          | 67.9                     | 375.3                    |
| "              | 300 | 1.67          | 776  | 4321 | 775    | 6.716  | Neg       | 5.19            | 3.97          | 76.0                     | 376.4                    |
| Defiant        | 300 | 0.64          | 85   | 9617 | 14.716 | 1.564  | Neg       | 3.95            | 7.21          | 22.1                     | 515.0                    |
| "              | 300 | 0.64          | 85   | 9647 | 14.14  | 1.557  | Neg       | 4.01            | 19.26         | 407.5                    | 50.6                     |
| Devastation    | 300 | 0.54          | 1474 | 9160 | 9667   | 17.961 | Neg       | 4.52            | 17.16         | 506.6                    | 174.6                    |
| "              | 300 | 0.54          | 1474 | 9160 | 9667   | 17.961 | Neg       | 3.11            | 7.75          | 732.1                    | 216.6                    |
| Adventure      | 302 | 10.77         | 642  | 2452 | 27     | 11.647 | Neg       | 1.766           | 2.63          | 6.74                     | 521.0                    |
| "              | 302 | 10.77         | 642  | 2470 | 126    | 10.417 | Neg       | 2.22            | 2.76          | 536.6                    | 297.6                    |
| "              | 302 | 10.77         | 647  | 2432 | 632    | 9.356  | Neg       | 1.36            | 3.14          | 561.7                    | 320.3                    |
| "              | 302 | 10.77         | 636  | 2906 | 517    | 8.567  | Neg       | 1.534           | 1.14          | 5.91                     | 379.5                    |
| Andromeda      | 300 | 0.518         | 907  | 5264 | 9755   | 15.405 | Neg       | 4.45            | 15.34         | 496.3                    | 130.6                    |
| "              | 300 | 0.518         | 1047 | 6170 | 917    | 12.629 | Neg       | 3.79            | 17.46         | 570.4                    | 174.6                    |
| "              | 300 | 0.518         | 907  | 5264 | 9666   | 16.611 | Neg       | 3.07            | 9.25          | 137.5                    | 136.1                    |
| "              | 300 | 0.518         | 907  | 5264 | 713    | 10.001 | Neg       | 1.71            | 5.40          | 604.4                    | 200.0                    |
| Active         | 370 | 0.68          | 672  | 3057 | 10     | 4.966  | Neg       | 6.14            | 19.66         | 527.5                    | 175.0                    |
| "              | 370 | 0.68          | 630  | 3057 | 3278   | 4.677  | Neg       | 7.65            | 14.61         | 564.5                    | 190.3                    |
| "              | 370 | 0.68          | 630  | 3167 | 3536   | 5.266  | Neg       | 5.71            | 9.71          | 623.9                    | 191.5                    |
| "              | 370 | 0.68          | 630  | 3057 | 1821   | 11.765 | Neg       | 1.91            | 2.90          | 606.8                    | 200.0                    |
| Regulus        | 300 | 0.45          | 1176 | 6010 | 3347   | 12.604 | Neg       | 2.94            | 7.06          | 604.0                    | 180.1                    |

\* Twin screw vessels.



RATIO OF EFFECTIVE TO INDICATED HORSE-POWER. (*Froude*.)*Indicated Thrust.*

- I = indicated thrust.  
 M = mean piston-pressure.  
 T = total piston-travel per revolution.  
 P = pitch of propeller.  
 N = number of revolutions.  
 IHP = indicated horse-power.

$$I = \frac{M \times T}{P} = \frac{33000 \times \text{IHP}}{P \times N}.$$

Indicated thrust is resolved into the following six elements:—

- No. 1. The ship's nett resistance, or useful thrust.
- No. 2. Augment of resistance due to negative pressure created about the ship's stern by the action of the screw. This is nearly proportional to the useful thrust.
- No. 3. Water friction of screw. This is also nearly proportional to the useful thrust.
- No. 4. Constant friction, or friction of engine without external load. This may also be taken as nearly proportional to the useful thrust.
- No. 5. Friction due to external load. This may be taken as constant at all speeds.
- No. 6. Air-pump and feed-pump resistance. This may be taken as nearly proportional to the square of the number of revolutions.

The above six elements are force factors, and when multiplied by  $\frac{\text{the speed of ship in feet per minute}}{33000}$  constitute the ship's horse-power as fundamentally due to her progress.

Let EHP = effective horse-power—that is, the power due to the nett resistance of the ship.

SHP = ship's horse-power.

IHP = indicated horse-power.

Then the ship's horse-power due to the several elements is as follows:—

Ship's horse-power due to No. 1 = EHP.

„ „ „ No. 2 = .4 EHP.

„ „ „ No. 3 = .1 EHP.

„ „ „ No. 4 = .143 SHP.

„ „ „ No. 5 = .143 SHP.

„ „ „ No. 6 = .075 SHP.

Or in combination  $\text{SHP} = 1.5 \text{ EHP} + .361 \text{ SHP}.$

So that  $.689 \text{ SHP} = 1.5 \text{ EHP};$

$$\text{or, SHP} = \frac{1.5}{.639} \text{ EHP} = 2.347 \text{ EHP.}$$

To this must be added—Slip = .1 SHP,  
making IHP = 1.1 SHP.

$$\text{Thus IHP} = 2.582 \text{ EHP} = \frac{100}{38.7} \text{ EHP ;}$$

$$\text{or, EHP} = .387 \text{ EHP.}$$

To convert the formula from one adapted to high speed only to one adapted to all speeds it is necessary to keep the term involving constant friction separate from the rest, for it represents simply the effect of a constant resistance operating with the existing speed of the engine.

In shaping the formula the coefficient 2.7, derived from rather broad experience, will be adhered to, instead of the coefficient 2.582, as the latter is built up from somewhat hypothetical data, assuming, however, that the constant friction is equal throughout to the one-seventh of the maximum load.

Of the 2.7 EHP which make up the IHP at the maximum speed  $v$ , one-seventh part, or .385, is the part due to constant friction, leaving 2.315 as due to the other sources of expenditure of power. And to express the IHP due to constant friction at any other speed  $v$ , the coefficient must be altered in the direct ratio of the speed, so that the term becomes  $\frac{v}{V} \times .385 \times \text{EHP}$  at designed maximum speed. Thus the formula for IHP at any speed  $v$  is as follows:—

$$\text{IHP} = 2.315 \text{ EHP} + .385 \frac{v}{V} \times (\text{EHP due to } v);$$

or, if the useful is finally severed from the collateral expenditure of power, it stands thus:—

$$\text{IHP} = \text{EHP} + 1.315 \text{ EHP} + .385 \frac{v}{V} \times (\text{EHP due to } v).$$

#### TO DETERMINE THE INITIAL AND CONSTANT FRICTION OF A MARINE ENGINE. (*Froude.*)

Construct a thrust curve (see fig. 146) by setting up ordinates  $y, y^1, y^2, y^3$ , &c., which represent to scale indicated thrusts taken at various speeds. The ordinates being set off at distances along the base line, commencing from the origin, so as to represent to scale the various speeds at which the thrust was taken, a curve bent through the ends of the ordinates will form part of a thrust curve. Let  $p$  be the lowest point found for the curve; at the point  $p$  draw the tangent  $pp'$ ; draw the vertical at  $h$  so as to cut the space  $Oy$  into segments, making  $Oy = 1.87 Oh$ ; draw a line

parallel to the base through the point  $e$ , where the vertical  $A$

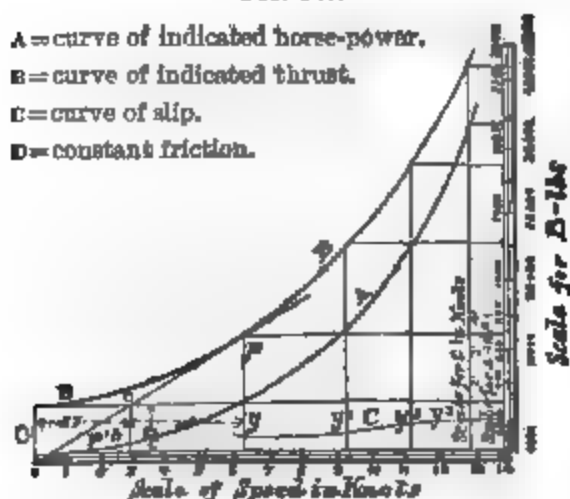
FIG. 146.

$A$  = curve of indicated horse-power.

$B$  = curve of indicated thrust.

$C$  = curve of slip.

$D$  = constant friction.



cuts the tangent  $pp'$ : the vertical height  $D$  between the parallel line and the base will represent the constant friction of the engine, and it will also be the height of the vertex of the thrust curve at the origin of the speed scale, which can thus be completed from the point  $p$ .

*Note.*—The heights of the ordinates above the line of constant friction, are proportional to the ship's true resistance.

## SPEED TRIALS.

### MEASURED MILE.

*To determine the true mean speed of a vessel when the runs are taken on the measured mile, half the number of runs being taken with the tide and half against the tide.*

**RULE.**—Find the means of consecutive speeds continually found until only one remains.

#### *Example.*

| Runs                 | Knots  | 1st Means                      | 2nd Means | 3rd Means | 4th Means | Mean of Means                |
|----------------------|--------|--------------------------------|-----------|-----------|-----------|------------------------------|
| 1st                  | 15.4   | 12.75                          | 12.475    | 12.45     | 12.425    | 12.46875<br>True mean speed. |
| 2nd                  | 10.1   |                                |           |           |           |                              |
| 3rd                  | 14.3   | 12.65                          | 12.375    | 12.3375   |           |                              |
| 4th                  | 11.0   | 12.10                          | 12.800    |           |           |                              |
| 5th                  | 13.2   | 12.50                          | 4 49.575  | 12.39375  |           |                              |
| 6th                  | 11.8   |                                |           |           |           |                              |
|                      | 6 75.8 |                                |           |           |           |                              |
|                      | 12.633 | Ordinary mean of second means. |           |           |           |                              |
| Ordinary mean speed. |        |                                |           |           |           |                              |

*Note.*—The ordinary mean of second means is generally taken as sufficiently accurate.

### SPEED OF THE CURRENT.

*To find the speeds of the current in the line of the ship's course during her speed trials.*

**RULE.**—Find the differences between the real speed of the ship and her observed speeds on the mile during the several runs.

Example.

| Runs | Observed Speed | Real Speed | Differences |                     |
|------|----------------|------------|-------------|---------------------|
| 1st  | 15.4           | 12.469     | 2.931       | Knots with the ship |
| 2nd  | 10.1           | 12.469     | 2.369       | „ against „         |
| 3rd  | 14.3           | 12.469     | 1.831       | „ with „            |
| 4th  | 11.0           | 12.469     | 1.469       | „ against „         |
| 5th  | 13.2           | 12.469     | .731        | „ with „            |
| 6th  | 11.8           | 12.469     | .669        | „ against „         |

SEA TRIALS.

To determine the true mean speed of a vessel when the distance is great.

RULE 1ST.—Calculate the apparent speed of each run as usual, by dividing the distance by the time, and group them in sets of three ; for example, 1, 2, 3 ; 2, 3, 4 ; 3, 4, 5 ; &c.

RULE 2ND.—Each set of three is to be treated as follows:—Find the two intervals of time between the middle instants of the first and second, and of the second and third runs of the set ; deduce those intervals to the corresponding angular intervals by the following proportion :—

As 12<sup>h</sup> 24<sup>m</sup> (the duration of a tide) : is to a given interval of time :: so is 360° : to the corresponding angular interval.

RULE 3RD.—Multiply the *first* apparent speed by the co-secant of the *first* angular interval, the *second* apparent speed by the sum of the co-tangents of the *two* angular intervals, the *third* apparent speed by the co-secant of the *second* angular interval.

RULE 4TH.—Add together the products and divide their sum by the sum of the before-mentioned multipliers ; the quotient will be a speed from which tidal effects have been eliminated.

RULE 5TH.—Add together the velocities deduced from the sets of three runs, and divide by their number for a final mean.

Note.—When an interval elapses of more than a quarter of a tide, or 3<sup>h</sup> 6<sup>m</sup>, between the middle instants of the two runs of a set, certain multipliers and products must be *subtracted*.

The following example will determine whether these certain multipliers are to be taken as positive or negative.

Example.

| Time.   | Angles.                        | Co-secants. | Co-tangents |
|---|--------------------------------|-------------|-------------|
| Between 0 <sup>h</sup> 0 <sup>m</sup> }<br>and 3 <sup>h</sup> 6 <sup>m</sup> }    | { Between 0° }<br>and 90° }    | Positive    | Positive.   |
| Between 3 <sup>h</sup> 6 <sup>m</sup> }<br>and 6 <sup>h</sup> 12 <sup>m</sup> }   | { Between 90° }<br>and 180° }  | Positive    | Negative.   |
| Between 6 <sup>h</sup> 12 <sup>m</sup> }<br>and 9 <sup>h</sup> 18 <sup>m</sup> }  | { Between 180° }<br>and 270° } | Negative    | Positive.   |
| Between 9 <sup>h</sup> 18 <sup>m</sup> }<br>and 12 <sup>h</sup> 24 <sup>m</sup> } | { Between 270° }<br>and 360° } | Negative    | Negative.   |

## SAILING.

## CENTRE OF LATERAL RESISTANCE.

*The centre of lateral resistance* is the centre of application of resistance of the water; and as this varies in position with the speed of the ship, &c., it is not determinate, but a point is generally taken at the centre of the immersed longitudinal vertical middle plane of the vessel as sufficiently accurate.

## CENTRE OF EFFORT.

The point in the longitudinal vertical middle plane of a vessel which is traversed by the resultant of the pressure of the wind on the sails is termed the centre of effort; its position varies according to the quantity of sail spread, &c., but its position is determined approximately for purposes connected with designing the sails, all plain sail only being taken—that is, the sails that are more commonly used, and which can be carried with safety in a fresh breeze (see table, p. 200). They are as follows:—

In square-rigged vessels: the fore and main courses, fore, main, and mizen topsails, fore, main, and mizen topgallant sails, driver, jib, and sometimes the fore topmast staysail.

In fore and aft rigged vessels: the main sail, fore sail, and sometimes the second or third jib.

In calculating the position of the centre of effort by the following rules the sails are taken braced right fore and aft.

*To find the perpendicular height of the centre of effort above the centre of lateral resistance.*

**RULE.**—Multiply the area of each sail by the height of its centre of gravity above the centre of lateral resistance; take the sum of those products (or moments) and divide it by the total area of sail: the quotient will be the required result.

*To find the lateral position of the centre of effort relatively to the centre of lateral resistance.*

**RULE 1.**—Multiply the area of each sail whose centre lies to one side of a vertical axis passing through the centre of lateral resistance by the perpendicular distance of its centre from that axis, and add the products (or moments) together.

**RULE 2.**—Treat the other sails whose centres lie to the other side of the axis of moments in the same way as before, and add their products together.

The difference between the two sums added together, and divided by the total area of sail, will give the perpendicular distance of the centre of effort from the given axis.

*Note.*—The centre of effort will lie to that side which has the greatest moment of sail.

*The following table shows the method in which the centre of effort is calculated.*

TABLE SHOWING METHOD OF CALCULATING THE POSITION OF THE CENTRE OF EFFORT RELATIVELY TO THE CENTRE OF LATERAL RESISTANCE.

| Name of Sail            | Areas   | Distances of Centre of Sail |       | Moments |          | Height of Centre of Sail Above | Vertical Moments |
|-------------------------|---------|-----------------------------|-------|---------|----------|--------------------------------|------------------|
|                         |         | Before                      | Abaft | Before  | Abaft    |                                |                  |
| Jib . . . . .           | 2040    | 188                         | —     | 281520  | —        | 87·3                           | 178092           |
| Fore course . . .       | 4050    | 78                          | —     | 315900  | —        | 56·0                           | 226800           |
| " topsail . . .         | 4350    | 78                          | —     | 337840  | —        | 109·5                          | 474185           |
| " topgallant sail . . . | 1500    | 78                          | —     | 117000  | —        | 158·8                          | 238200           |
| Main course . . .       | 5488    | —                           | 12·5  | —       | 67600    | 58·3                           | 315280·4         |
| " topsail . . .         | 5440    | —                           | 14·0  | —       | 76160    | 117·8                          | 638112           |
| " topgallant sail . . . | 1881    | —                           | 15·5  | —       | 29155·5  | 172·0                          | 324532           |
| Driver . . . . .        | 2831·5  | —                           | 100·5 | —       | 284565·7 | 62·5                           | 176968·7         |
| Mizen topsail . .       | 2615    | —                           | 78·0  | —       | 206310   | 99·5                           | 263177·5         |
| " topgallant sail . .   | 902     | —                           | 79·5  | —       | 71709    | 186·0                          | 122672           |
|                         | 31027·5 |                             |       | 1052260 | 785500·2 |                                | 2957975·6        |

Hght. of Centre of Effort above  
Centre of Lateral Resistance } =  $\frac{\text{moment } 2957975·6}{\text{area } 31027·5} = 95·3.$

Dist. of Centre of Effort before  
Centre of Lateral Resistance } =  $\frac{\text{moments } 1052260 - 785500·2}{\text{area } 31027·5} = 10·2.$

#### ARDENCY.

Ardency is the tendency a ship has to fly up to the wind, thus showing that the position of her centre of effort is abaft the centre of lateral resistance.

#### SLACKNESS.

Slackness is the tendency a ship has to fall off from the wind, thus showing that the position of her centre of effort is before the centre of lateral resistance.



### RELATIVE POSITION OF CENTRE OF EFFORT AND CENTRE OF LATERAL RESISTANCE.

$D$  = distance of centre of effort before centre of lateral resistance.

$D_1$  = distance of centre of effort above centre of lateral resistance.

$L$  = length of load water-line.

$A$  = area of load water-line.

$d$  = distance of centre of buoyancy of ship below load water-line.

$d_1$  = distance of centre of lateral resistance abaft the middle of the load water-line.

$d_2$  = distance of centre of buoyancy before the middle of the load water-line.

$$D = \frac{L(\frac{3}{4}d_1 + d_2)}{10(d_1 + d_2)} \text{ for square-rigged vessels.}$$

$$D = \frac{L}{10(d_1 + d_2)} \text{ for cutter and fore and aft rigged vessels.}$$

$$D_1 = \frac{4A}{5d}.$$

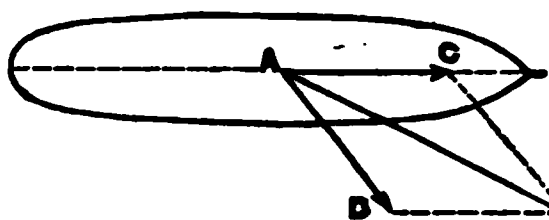
*Note.*—The centre of effort of the sails, to produce the best effect, must be higher or lower according as the ship is more or less full at the load water-line compared with the fulness of the body at the extremities below the water. Ships that are full at the load water-line and clean below at the extremities require the higher masts.

### REAL AND APPARENT MOTION OF THE WIND.

By the real motion of the wind is meant its motion relatively to the earth, and by its apparent motion its motion relatively to the ship when she is sailing.

The apparent motion being the resultant of the real motion of the wind and of a motion equal and directly opposite to that of the ship.

FIG. 147.



In fig. 147 let  $AB$  represent in magnitude and direction the real motion of the wind, and  $AC$  the direction and velocity of the motion of the ship; through  $B$  draw  $BD$  parallel and equal to  $AC$ ; join  $DA$ : then

$DA$  will represent in magnitude and direction the apparent motion of the wind.

In algebraical symbols let—

$a$  = angle ADB made by the point from which the apparent wind blows with the course of the ship.

$K = 180 - a$  = supplement of ADB, the corresponding angle for the real wind.

$r = \frac{AD}{DB}$  = ratio of velocity of apparent wind to that of the ship.

$r_1 = \frac{AB}{DB}$  = ratio of velocity of real wind to that of the ship.

$$r = \{ \sqrt{(r_1^2 - 1 + \cos^2 a)} + \cos a \}.$$

When  $a$  is obtuse,  $r = \{ \sqrt{(r_1^2 - 1 + \cos^2 a)} - \cos a \}.$

$$r = \sqrt{(1 + r_1^2 + 2r_1 \cdot \cos K)}.$$

When  $K$  is obtuse,  $r = \sqrt{(1 + r_1^2 - 2r_1 \cos K)}.$

$$r_1 = \sqrt{(1 + r^2 - 2r \cdot \cos a)}.$$

When  $a$  is obtuse,  $r = \sqrt{(1 + r^2 + 2r \cdot \cos a)}.$

$$\sin K = \frac{r}{r_1} \sin a.$$

$$\sin a = \frac{r_1}{r} \sin K.$$

#### EFFECTIVE IMPULSE OF WIND.

$D$  = direct impulse of wind on sails in lbs.

$E$  = effective impulse of wind on sails in lbs.

$C$  = component of effective impulse which produces leeway and tends to heel the ship over.

$C_1$  = component of effective impulse which moves the ship ahead.

$\theta$  = angle made by direction of apparent motion of wind with the plane of the sails (see fig. 148).

$a$  = angle made by the plane of the sails with the ship's course (see fig. 148).

$$E = D \sin^2 \theta. \quad C = E \cos a. \quad C_1 = E \sin a.$$

In fig. 148 let PC represent in magnitude and direction the pressure of the apparent wind on the sail AB; through P draw PR parallel to AB; through C draw CR perpendicular to PR and cutting PR in R: then RC is the effective pressure of the wind on the sail AB, and RN perpendicular to KM is the component of RC which produces heel and leeway, while NC is the component of RC which propels the ship along.

FIG. 148.

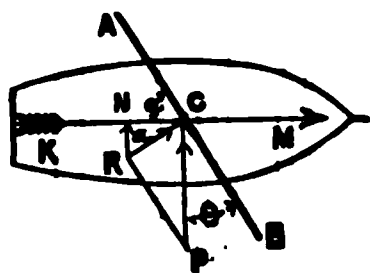


TABLE OF DIRECT IMPULSE OF WINDS IN LBS. PER SQUARE FOOT, AND SAILS COMMONLY SET BY THE WIND.

| Velocity<br>in Knots<br>per Hour | Impulse<br>in lbs. | Name of Wind       | Sails commonly set by the Wind  |
|----------------------------------|--------------------|--------------------|---|
| 1                                | ·0067              | Light air          | Courses, topsails, topgal-<br>lant sails, royals, spanker,<br>jib, flying j.b, and all<br>light sails.  |
| 2                                | ·027               |                    |   |
| 3                                | ·060               |                    |   |
| 4                                | ·107               | Light wind         |   |
| 5                                | ·167               |                    |   |
| 6                                | ·240               |                    |   |
| 7                                | ·327               | Light breeze       |   |
| 8                                | ·427               |                    |   |
| 9                                | ·540               | Moderate<br>breeze |   |
| 10                               | ·667               |                    |   |
| 11                               | ·807               | Fresh breeze       | Royals and flying jib taken<br>in in a sea way to two<br>reefs in the topsails.   |
| 12                               | ·960               |                    |   |
| 13                               | 1·13               |                    |   |
| 14                               | 1·31               | Strong breeze      |   |
| 15                               | 1·50               |                    |   |
| 16                               | 1·71               |                    |   |
| 17                               | 1·93               |                    |   |
| 18                               | 2·16               |                    |   |
| 19                               | 2·41               |                    |   |
| 20                               | 2·67               | Moderate<br>gale   | Single-reefed topsails and<br>topgallant sails in much<br>sea, two reefs in the top-<br>sails to taking in topgal-<br>lant sails.   |
| 22                               | 3·23               |                    |   |
| 24                               | 3·84               |                    |   |
| 26                               | 4·51               | Fresh gale         | Double-reefed topsails to<br>treble-reefed topsails,<br>reefed spanker and jib.<br>Close-reefed topsails, reefed<br>courses to taking in span-<br>ker, jib, fore and mizen<br>topsails. |
| 28                               | 5·23               |                    |   |
| 30                               | 6·00               |                    |   |
| 32                               | 6·83               | Strong gale        |   |
| 34                               | 7·71               |                    |   |
| 36                               | 8·64               |                    |   |
| 38                               | 9·63               | Heavy gale         | Close-reefed main topsail<br>to storm staysails, or close-<br>reefed main topsail only.   |
| 40                               | 10·7               |                    |   |
| 45                               | 13·5               | Storm              |   |
| 50                               | 18·7               |                    |   |
| 55                               | 24·0               |                    |   |
| 60                               | 32·7               | Hurricane          |   |
| 70                               | 48·7               |                    |   |
| 80                               | 64·0               |                    |   |
| 90                               | 80·7               |                    |   |
| 100                              | 100·7              |                    |   |

**V** = velocity of wind in knots per hour.  
**D** = direct impulse in lbs. on one square foot.

$$D = \frac{v^2}{150} = v^2 \cdot 0.006667.$$

$v$  = velocity of ship.                       $D$  = displacement of ship.  
 $x$  = area of midship section.            $A$  = area of sails.  
 $c$  and  $c_1$  = constants obtained from similar vessels.

$$V = c \sqrt{\frac{A}{X}} = c_1 \sqrt{\frac{A}{D_2^2}}$$

$$c_1 = \sqrt{\frac{V^2 D^2}{A}}$$

$$C = \sqrt{\frac{V^2 X}{A}}.$$

$$\mathbf{A} = \frac{V^2 \mathbf{X}}{c^2} = \frac{V^2 D \frac{2}{3}}{c_1^2}.$$

| Ratio of Area of Sails to Augmented Surface | Relation between Course and Wind             | Probable Ratio of Speed of Ship to Sp. of Real Wind |
|---|--|---|
| 1   | Course 5 points near wind . . .              | $\frac{1}{2}$                                       |
|   | Wind 2 points abaft beam . . .               | $\frac{1}{2}$                                       |
| $1\frac{1}{2}$                              | Course 6 points near wind . . .              | $\frac{2}{3}$                                       |
|   | Wind abeam . . . . .                         | $\frac{2}{3}$                                       |
|   | Wind astern . . . . .                        | $\frac{2}{3}$                                       |
| 2   | Course 5 points near wind . . .              | $\frac{3}{4}$                                       |
|   | Wind 2 points abaft beam . . .               | $\frac{3}{4}$                                       |
| $2\frac{1}{2}$                              | Course about $6\frac{1}{2}$ points near wind | $\frac{4}{5}$                                       |
|   | Wind on quarter . . . . .                    | $\frac{4}{5}$                                       |

| Speed under canvas ÷ speed under steam | Probable speed under steam and canvas ÷ speed under steam | Speed under canvas ÷ speed under steam | Probable speed under steam and canvas ÷ speed under steam |
|--|---|--|---|
| ·4                                     | 1·02  | 1·8                                    | 1·47  |
| ·5                                     | 1·04  | 1·4                                    | 1·55  |
| ·6                                     | 1·07  | 1·5                                    | 1·64  |
| ·7                                     | 1·10  | 1·6                                    | 1·72  |
| ·8                                     | 1·15  | 1·7                                    | 1·81  |
| ·9                                     | 1·20  | 1·8                                    | 1·90  |
| 1·0                                    | 1·26  | 1·9                                    | 1·99  |
| 1·1                                    | 1·33  | 2·0                                    | 2·08  |
| 1·2                                    | 1·40  | —                                      | —   |

| Speed. under canvas + speed under steam | Probable speed under steam and canvas ÷ speed under steam | Speed under canvas ÷ speed under steam | Probable speed under steam and canvas ÷ speed under steam |
|---|---|--|---|
| ·4                                      | 1·02  | 1·3                                    | 1·47  |
| ·5                                      | 1·04  | 1·4                                    | 1·55  |
| ·6                                      | 1·07  | 1·5                                    | 1·64  |
| ·7                                      | 1·10  | 1·6                                    | 1·72  |
| ·8                                      | 1·15  | 1·7                                    | 1·81  |
| ·9                                      | 1·20  | 1·8                                    | 1·90  |
| 1·0                                     | 1·26  | 1·9                                    | 1·99  |
| 1·1                                     | 1·33  | 2·0                                    | 2·08  |
| 1·2                                     | 1·40  | —                                      | —   |

## HEELING MOMENT OF SAILS.

$E$  = effective impulse of wind on sails in lbs. (see p. 199).

$D$  = displacement of vessel in lbs.

$C$  = height of centre of effort above centre of lateral resistance.

$G$  = height metacentre above centre of gravity.

$L$  = length of arm of righting couple at a given angle of heel.

$M$  = heeling moment of sails.

$a$  = angle made by plane of sails with course of ship (see fig. 148).

$\theta$  = angle of heel of vessel.

$$M = C \cdot E \cdot \cos a \cdot \cos \theta.$$

The steady angle of heel of a vessel due to  $M$  will be that at which

$$M = D \cdot G \cdot \sin \theta \quad (\text{for small angles of heel}),$$

$$M = L \cdot D \quad (\text{for any angle of heel}).$$

In the two last formulæ the reduction in the effective heeling power of the wind due to the sails being inclined from the upright position has been neglected, but if necessary the diminution of the effective pressure of the wind may be taken to vary as the sine squared of the angle of incidence of the wind with the plane of the ship's sails, or as the cosine squared of the angle of heel.

*Note.*—In a general sense the moment of sail is usually understood to be the product of the area of all plain sail into the height of the centre of effort above the centre of lateral resistance, as the pressure of wind is generally taken as one pound in the square foot; and the product of the weight of the ship in lbs. into the height of the metacentre above the centre of gravity, divided by the moment of sail, is taken as a measure of her efficiency to resist inclination under canvas.

## AREA OF SAIL.

To determine accurately the quantity of sail suitable for any vessel to carry, make the moment of sail equal to the moment of stability at a definite angle of heel; but the following rule may generally be taken as sufficiently approximate:—

$A$  = quantity of sail suitable to a given vessel.

$D$  = displacement of vessel in lbs.

$M$  = height of metacentre above centre of gravity.

$H$  = height of centre of effort above centre of lateral resistance.

$\theta$  = angle of heel in circular measure suitable to given vessel taken from the following table.

$$A = \frac{D \times M \times \theta}{H}$$

TABLE OF ANGLE OF STEADY HEEL FOR DIFFERENT CLASSES OF VESSELS.

| Class of Vessel                   | Angle of Heel | Circular Measure |
|-----------------------------------|---------------|------------------|
| Frigates and large merchant ships | 4°            | ·070             |
| Corvettes                         | 5°            | ·087             |
| Schooners and cutters             | 6°            | ·105             |
| Yachts                            | 6° to 9°      | ·105 to ·107     |

TABLE OF THE AREA AND MOMENT OF SAILS OF SOME OF HER MAJESTY'S SCREW VESSELS.

|                | A     | B     | C    | D      | E     | F       | G     | H     |
|----------------|-------|-------|------|--------|-------|---------|-------|-------|
|                |       |       |      |        |       | ft. in. |       |       |
| Achilles       | 80133 | 22·6  | 3·11 | 95·99  | 23·33 | 26 10   | 1·517 | 3·088 |
| Bellerophon    | 23792 | 19·34 | 3·15 | 85·64  | 26·1  | 24 8½   | 2·03  | 3·28  |
| Favourite      | 16206 | 20·62 | 5·01 | 105·4  | 21·2  | 21 4    | 1·00  | 3·40  |
| Hercules       | 28882 | 21·62 | 3·26 | 118·42 | 18·9  | 24 0½   | 1·38  | 2·69  |
| Inconstant     | 26034 | 27·57 | 4·61 | 147·9  | 15·1  | 23 10½  | 1·42  | 2·80  |
| Iron Duke      | 25054 | 23·92 | 4·25 | 128·96 | 17·3  | 22 0    | ·66   | 3·012 |
| Monarch        | 27700 | 22·52 | 3·35 | 129·12 | 17·3  | 24 1½   | ·76   | 2·37  |
| Minotaur       | 32377 | 24·23 | 3·10 | 74·50  | 30·0  | 26 8½   | 1·999 | 3·879 |
| Penelope       | 17168 | 22·32 | 3·93 | 84·35  | 26·6  | 16 6½   | 1·35  | 3·62  |
| Prince Consort | 22459 | 18·85 | 3·36 | 43·28  | 51·7  | 25 5    | 2·15  | 6·01  |
| Sultan         | 28258 | 20·42 | 3·07 | 112·84 | 19·8  | 26 0    | 2·33  | 2·64  |
| Swiftsure      | 25095 | 21·95 | 3·82 | 116·0  | 19·3  | 24 10½  | 1·8   | 3·05  |
| Valiant        | 21426 | 17·49 | 3·18 | 59·10  | 37·9  | 25 8    | 1·89  | 4·61  |
| Vixen          | 7860  | 22·98 | 6·39 | 74·67  | 29·9  | 11 2½   | ·95   | 4·21  |
| Warrior        | 28809 | 23·07 | 3·16 | 63·22  | 35·4  | 26 5½   | 2·286 | 4·678 |

In the above table—

A = area of plain sail in square feet.

B = proportion of sail to one foot of midship section at load draught.

C = proportion of sail to one ton of displacement at load draught.

D = moment of sail about centre of lateral resistance divided by displacement in tons into the distance between the metacentre and the centre of gravity in feet.

E = weight of the ship in lbs. multiplied by the distance between the metacentre and the centre of gravity, and the product divided by the moment of sail about the centre of lateral resistance.

*Note.*—This is a measure of the power of a ship to resist inclination under her canvas.

$R$  = mean load draught of water in feet and inches.

$G$  = distance of centre of gravity below load water-line in feet.

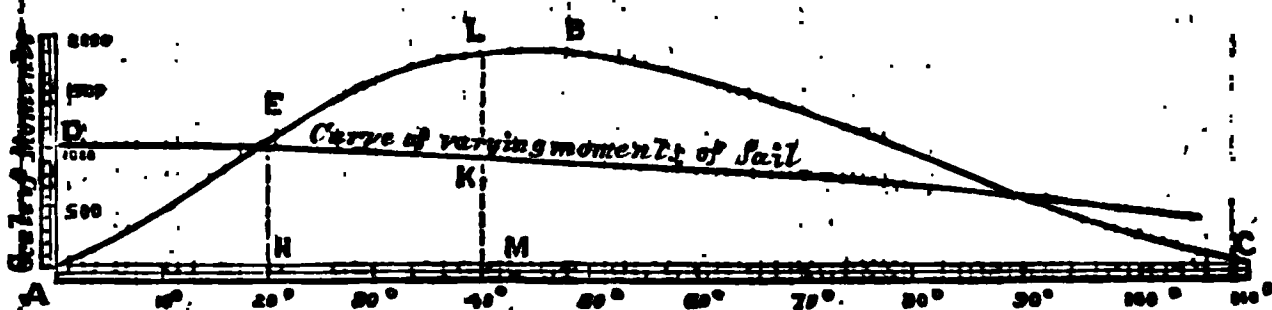
$H$  = height of metacentre above centre of gravity in feet.

#### EFFECT OF GUST OF WIND ON A SHIP'S SAILS.

The effect of a sudden gust of wind upon a ship's sails is, as a rule, to heel her over to an extreme angle of heel of about twice the steady angle at which the same constant pressure of wind would keep her.

In fig. 149. let  $ABC$  be the ship's curve of statical stability, and  $DE$  her curve of varying moments of sail—that is, the ordinates which express the moment of sail at the different angles vary as the cosine<sup>2</sup> of the angle of heel.

FIG. 149.



If the wind is steadily applied the ship will remain inclined at a steady angle of heel of  $20^\circ$ , determined by dropping an ordinate at the point of intersection  $E$  of the two curves; but in the case of the same pressure of wind being suddenly applied she will heel over beyond the steady angle of heel, and she will oscillate for a time about that angle, the reason being that an amount of mechanical work has been done in heeling her over to  $20^\circ$ , which is represented by the area  $ADEH$ , whereas the work absorbed is only equal in area to  $AEH$ ; hence mechanical work has been accumulated equal to the area  $AED$ . The ship will therefore continue to heel over till this work has been absorbed; this will occur at  $40^\circ$ , when the area  $EKL$  is equal to the area  $AED$ , or, in other words, when the area  $ALM$ —the dynamical stability at  $40^\circ$ —is equal to the area  $ADKM$  she will commence a return oscillation under the influence of a righting moment, represented by  $KL$ .

# TIME AND KNOT TABLE

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour.

| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
| 0     | 30.000 | 20.000 | 15.000 | 12.000 | 10.000 | 8.571  | 7.500  | 6.667  | 6.000   | 5.455   | 5.000   | 4.615   | 4.286   |
| 1     | 29.752 | 19.890 | 14.938 | 11.960 | 9.972  | 8.551  | 7.484  | 6.654  | 5.990   | 5.446   | 4.993   | 4.609   | 4.281   |
| 2     | 29.508 | 19.780 | 14.876 | 11.921 | 9.945  | 8.531  | 7.469  | 6.642  | 5.980   | 5.438   | 4.986   | 4.604   | 4.275   |
| 3     | 29.268 | 19.672 | 14.815 | 11.881 | 9.917  | 8.511  | 7.453  | 6.630  | 5.970   | 5.430   | 4.979   | 4.598   | 4.270   |
| 4     | 29.032 | 19.565 | 14.754 | 11.842 | 9.890  | 8.491  | 7.438  | 6.618  | 5.960   | 5.422   | 4.972   | 4.592   | 4.265   |
| 5     | 28.800 | 19.459 | 14.694 | 11.803 | 9.863  | 8.471  | 7.423  | 6.606  | 5.950   | 5.414   | 4.965   | 4.586   | 4.260   |
| 6     | 28.571 | 19.355 | 14.634 | 11.765 | 9.836  | 8.451  | 7.407  | 6.593  | 5.941   | 5.405   | 4.959   | 4.580   | 4.255   |
| 7     | 28.346 | 19.251 | 14.575 | 11.726 | 9.809  | 8.431  | 7.392  | 6.581  | 5.931   | 5.397   | 4.952   | 4.574   | 4.250   |
| 8     | 28.125 | 19.149 | 14.516 | 11.688 | 9.783  | 8.411  | 7.377  | 6.569  | 5.921   | 5.389   | 4.945   | 4.568   | 4.245   |
| 9     | 27.907 | 19.048 | 14.458 | 11.650 | 9.756  | 8.392  | 7.362  | 6.557  | 5.911   | 5.381   | 4.938   | 4.563   | 4.240   |
| 10    | 27.692 | 18.947 | 14.400 | 11.613 | 9.730  | 8.372  | 7.347  | 6.545  | 5.902   | 5.373   | 4.931   | 4.557   | 4.235   |
| 11    | 27.481 | 18.848 | 14.343 | 11.576 | 9.704  | 8.353  | 7.332  | 6.534  | 5.892   | 5.365   | 4.925   | 4.551   | 4.230   |
| 12    | 27.273 | 18.750 | 14.286 | 11.539 | 9.677  | 8.333  | 7.317  | 6.522  | 5.882   | 5.357   | 4.918   | 4.545   | 4.225   |
| 13    | 27.068 | 18.653 | 14.229 | 11.502 | 9.651  | 8.314  | 7.302  | 6.510  | 5.873   | 5.349   | 4.911   | 4.540   | 4.220   |
| 14    | 26.866 | 18.557 | 14.173 | 11.465 | 9.626  | 8.295  | 7.287  | 6.498  | 5.863   | 5.341   | 4.905   | 4.534   | 4.215   |
| 15    | 26.667 | 18.461 | 14.118 | 11.429 | 9.600  | 8.276  | 7.273  | 6.486  | 5.854   | 5.333   | 4.898   | 4.528   | 4.210   |
| 16    | 26.471 | 18.367 | 14.062 | 11.392 | 9.574  | 8.257  | 7.258  | 6.475  | 5.844   | 5.325   | 4.891   | 4.523   | 4.206   |
| 17    | 26.277 | 18.274 | 14.008 | 11.356 | 9.549  | 8.238  | 7.243  | 6.463  | 5.835   | 5.318   | 4.885   | 4.517   | 4.201   |
| 18    | 26.087 | 18.182 | 13.953 | 11.321 | 9.524  | 8.219  | 7.229  | 6.452  | 5.826   | 5.310   | 4.878   | 4.511   | 4.196   |
| 19    | 25.899 | 18.090 | 13.900 | 11.285 | 9.499  | 8.200  | 7.214  | 6.440  | 5.816   | 5.302   | 4.871   | 4.506   | 4.191   |
| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |



## TIME AND KNOT TABLE (continued).

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour

| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
| 20    | 25-714 | 18-000 | 13-846 | 11-250 | 9-474  | 8-182  | 7-200  | 6-429  | 5-806   | 5-294   | 4-865   | 4-500   | 4-186   |
| 21    | 25-532 | 17-910 | 13-793 | 11-215 | 9-449  | 8-163  | 7-186  | 6-417  | 5-797   | 5-286   | 4-858   | 4-494   | 4-181   |
| 22    | 25-352 | 17-822 | 13-740 | 11-180 | 9-424  | 8-145  | 7-171  | 6-406  | 5-788   | 5-279   | 4-852   | 4-489   | 4-176   |
| 23    | 25-175 | 17-734 | 13-688 | 11-146 | 9-399  | 8-126  | 7-157  | 6-394  | 5-778   | 5-271   | 4-845   | 4-483   | 4-171   |
| 24    | 25-000 | 17-647 | 13-636 | 11-111 | 9-375  | 8-108  | 7-143  | 6-383  | 5-769   | 5-263   | 4-839   | 4-478   | 4-167   |
| 25    | 24-828 | 17-561 | 13-585 | 11-077 | 9-351  | 8-090  | 7-129  | 6-372  | 5-760   | 5-255   | 4-832   | 4-472   | 4-162   |
| 26    | 24-658 | 17-476 | 13-534 | 11-043 | 9-326  | 8-072  | 7-115  | 6-360  | 5-751   | 5-248   | 4-826   | 4-466   | 4-157   |
| 27    | 24-490 | 17-391 | 13-483 | 11-009 | 9-302  | 8-054  | 7-101  | 6-349  | 5-742   | 5-240   | 4-819   | 4-461   | 4-152   |
| 28    | 24-324 | 17-308 | 13-433 | 10-976 | 9-278  | 8-036  | 7-087  | 6-338  | 5-732   | 5-233   | 4-813   | 4-455   | 4-147   |
| 29    | 24-161 | 17-225 | 13-383 | 10-943 | 9-254  | 8-018  | 7-073  | 6-327  | 5-723   | 5-225   | 4-806   | 4-450   | 4-143   |
| 30    | 24-000 | 17-143 | 13-333 | 10-909 | 9-231  | 8-000  | 7-059  | 6-316  | 5-714   | 5-217   | 4-800   | 4-444   | 4-138   |
| 31    | 23-841 | 17-062 | 13-284 | 10-876 | 9-207  | 7-982  | 7-045  | 6-305  | 5-705   | 5-210   | 4-794   | 4-439   | 4-133   |
| 32    | 23-684 | 16-981 | 13-235 | 10-843 | 9-184  | 7-965  | 7-031  | 6-294  | 5-696   | 5-202   | 4-787   | 4-433   | 4-128   |
| 33    | 23-529 | 16-901 | 13-187 | 10-811 | 9-160  | 7-947  | 7-018  | 6-283  | 5-687   | 5-195   | 4-781   | 4-428   | 4-124   |
| 34    | 23-377 | 16-822 | 13-139 | 10-778 | 9-137  | 7-930  | 7-004  | 6-272  | 5-678   | 5-187   | 4-774   | 4-423   | 4-119   |
| 35    | 23-226 | 16-744 | 13-091 | 10-746 | 9-114  | 7-912  | 6-990  | 6-261  | 5-669   | 5-180   | 4-768   | 4-417   | 4-114   |
| 36    | 23-077 | 16-667 | 13-043 | 10-714 | 9-091  | 7-895  | 6-977  | 6-250  | 5-660   | 5-172   | 4-762   | 4-412   | 4-110   |
| 37    | 22-930 | 16-590 | 12-996 | 10-682 | 9-068  | 7-877  | 6-963  | 6-239  | 5-651   | 5-165   | 4-756   | 4-406   | 4-105   |
| 38    | 22-785 | 16-514 | 12-950 | 10-651 | 9-045  | 7-860  | 6-950  | 6-228  | 5-643   | 5-158   | 4-749   | 4-401   | 4-100   |
| 39    | 22-642 | 16-438 | 12-903 | 10-619 | 9-023  | 7-843  | 6-936  | 6-218  | 5-634   | 5-150   | 4-743   | 4-396   | 4-096   |
| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |

# TIME AND KNOT TABLE (concluded).

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour.

| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
| 40    | 22.500 | 16.364 | 12.857 | 10.588 | 9.000  | 7.826  | 6.923  | 6.207  | 5.625   | 5.143   | 4.737   | 4.390   | 4.091   |
| 41    | 22.360 | 16.290 | 12.811 | 10.557 | 8.978  | 7.809  | 6.910  | 6.196  | 5.616   | 5.136   | 4.731   | 4.385   | 4.086   |
| 42    | 22.222 | 16.216 | 12.766 | 10.526 | 8.955  | 7.792  | 6.897  | 6.186  | 5.607   | 5.128   | 4.724   | 4.379   | 4.082   |
| 43    | 22.086 | 16.143 | 12.721 | 10.496 | 8.933  | 7.775  | 6.883  | 6.175  | 5.599   | 5.121   | 4.718   | 4.374   | 4.077   |
| 44    | 21.951 | 16.071 | 12.676 | 10.465 | 8.911  | 7.759  | 6.870  | 6.164  | 5.590   | 5.114   | 4.712   | 4.369   | 4.072   |
| 45    | 21.818 | 16.000 | 12.632 | 10.435 | 8.889  | 7.742  | 6.857  | 6.154  | 5.581   | 5.106   | 4.706   | 4.364   | 4.068   |
| 46    | 21.687 | 15.929 | 12.587 | 10.405 | 8.867  | 7.725  | 6.844  | 6.143  | 5.573   | 5.099   | 4.700   | 4.358   | 4.063   |
| 47    | 21.557 | 15.859 | 12.544 | 10.375 | 8.845  | 7.709  | 6.831  | 6.133  | 5.564   | 5.092   | 4.693   | 4.353   | 4.059   |
| 48    | 21.429 | 15.789 | 12.500 | 10.345 | 8.824  | 7.692  | 6.818  | 6.122  | 5.556   | 5.085   | 4.687   | 4.348   | 4.054   |
| 49    | 21.302 | 15.721 | 12.457 | 10.315 | 8.802  | 7.676  | 6.805  | 6.112  | 5.547   | 5.078   | 4.681   | 4.343   | 4.049   |
| 50    | 21.176 | 15.652 | 12.414 | 10.286 | 8.780  | 7.660  | 6.792  | 6.102  | 5.538   | 5.070   | 4.675   | 4.337   | 4.045   |
| 51    | 21.053 | 15.584 | 12.371 | 10.256 | 8.759  | 7.643  | 6.780  | 6.091  | 5.530   | 5.063   | 4.669   | 4.332   | 4.040   |
| 52    | 20.930 | 15.517 | 12.329 | 10.227 | 8.738  | 7.627  | 6.767  | 6.081  | 5.521   | 5.056   | 4.663   | 4.327   | 4.035   |
| 53    | 20.809 | 15.451 | 12.287 | 10.198 | 8.717  | 7.611  | 6.754  | 6.071  | 5.513   | 5.049   | 4.657   | 4.322   | 4.031   |
| 54    | 20.690 | 15.385 | 12.245 | 10.169 | 8.696  | 7.595  | 6.742  | 6.061  | 5.505   | 5.042   | 4.651   | 4.316   | 4.027   |
| 55    | 20.571 | 15.319 | 12.203 | 10.141 | 8.675  | 7.579  | 6.729  | 6.050  | 5.496   | 5.035   | 4.645   | 4.311   | 4.022   |
| 56    | 20.455 | 15.254 | 12.162 | 10.112 | 8.654  | 7.563  | 6.716  | 6.040  | 5.488   | 5.028   | 4.639   | 4.306   | 4.018   |
| 57    | 20.339 | 15.190 | 12.121 | 10.084 | 8.633  | 7.547  | 6.704  | 6.030  | 5.479   | 5.021   | 4.633   | 4.301   | 4.013   |
| 58    | 20.225 | 15.126 | 12.081 | 10.056 | 8.612  | 7.531  | 6.691  | 6.020  | 5.471   | 5.014   | 4.627   | 4.296   | 4.009   |
| 59    | 20.112 | 15.063 | 12.040 | 10.028 | 8.592  | 7.516  | 6.679  | 6.010  | 5.463   | 5.007   | 4.621   | 4.291   | 4.004   |
| secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |

# TIME AND KNOT TABLE (continued).

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour.

| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
| 20    | 25.714 | 18.000 | 13.846 | 11.250 | 9.474  | 8.182  | 7.200  | 6.429  | 5.806   | 5.294   | 4.865   | 4.500   | 4.186   |
| 21    | 25.532 | 17.910 | 13.793 | 11.215 | 9.449  | 8.163  | 7.186  | 6.417  | 5.797   | 5.286   | 4.858   | 4.494   | 4.181   |
| 22    | 25.352 | 17.822 | 13.740 | 11.180 | 9.424  | 8.145  | 7.171  | 6.406  | 5.788   | 5.279   | 4.852   | 4.489   | 4.176   |
| 23    | 25.175 | 17.734 | 13.688 | 11.146 | 9.399  | 8.126  | 7.157  | 6.394  | 5.778   | 5.271   | 4.845   | 4.483   | 4.171   |
| 24    | 25.000 | 17.647 | 13.636 | 11.111 | 9.375  | 8.108  | 7.143  | 6.383  | 5.769   | 5.263   | 4.839   | 4.478   | 4.167   |
| 25    | 24.828 | 17.561 | 13.585 | 11.077 | 9.351  | 8.090  | 7.129  | 6.372  | 5.760   | 5.255   | 4.832   | 4.472   | 4.162   |
| 26    | 24.658 | 17.476 | 13.534 | 11.043 | 9.326  | 8.072  | 7.115  | 6.360  | 5.751   | 5.248   | 4.826   | 4.466   | 4.157   |
| 27    | 24.490 | 17.391 | 13.483 | 11.009 | 9.302  | 8.054  | 7.101  | 6.349  | 5.742   | 5.240   | 4.819   | 4.461   | 4.152   |
| 28    | 24.324 | 17.308 | 13.433 | 10.976 | 9.278  | 8.036  | 7.087  | 6.338  | 5.732   | 5.233   | 4.813   | 4.455   | 4.147   |
| 29    | 24.161 | 17.225 | 13.383 | 10.942 | 9.254  | 8.018  | 7.073  | 6.327  | 5.723   | 5.225   | 4.806   | 4.450   | 4.143   |
| 30    | 24.000 | 17.143 | 13.333 | 10.909 | 9.231  | 8.000  | 7.059  | 6.316  | 5.714   | 5.217   | 4.800   | 4.444   | 4.138   |
| 31    | 23.841 | 17.062 | 13.284 | 10.876 | 9.207  | 7.982  | 7.045  | 6.305  | 5.705   | 5.210   | 4.794   | 4.439   | 4.133   |
| 32    | 23.684 | 16.981 | 13.235 | 10.843 | 9.184  | 7.965  | 7.031  | 6.294  | 5.696   | 5.202   | 4.787   | 4.433   | 4.128   |
| 33    | 23.529 | 16.901 | 13.187 | 10.811 | 9.160  | 7.947  | 7.018  | 6.283  | 5.687   | 5.195   | 4.781   | 4.428   | 4.124   |
| 34    | 23.377 | 16.822 | 13.139 | 10.778 | 9.137  | 7.930  | 7.004  | 6.272  | 5.678   | 5.187   | 4.774   | 4.423   | 4.119   |
| 35    | 23.226 | 16.744 | 13.091 | 10.746 | 9.114  | 7.912  | 6.990  | 6.261  | 5.669   | 5.180   | 4.768   | 4.417   | 4.114   |
| 36    | 23.077 | 16.667 | 13.043 | 10.714 | 9.091  | 7.895  | 6.977  | 6.250  | 5.660   | 5.172   | 4.762   | 4.412   | 4.110   |
| 37    | 22.930 | 16.590 | 12.996 | 10.682 | 9.068  | 7.877  | 6.963  | 6.239  | 5.651   | 5.165   | 4.756   | 4.406   | 4.105   |
| 38    | 22.785 | 16.514 | 12.950 | 10.651 | 9.045  | 7.860  | 6.950  | 6.228  | 5.643   | 5.158   | 4.749   | 4.401   | 4.100   |
| 39    | 22.642 | 16.438 | 12.903 | 10.619 | 9.023  | 7.843  | 6.936  | 6.218  | 5.634   | 5.150   | 4.743   | 4.396   | 4.096   |
| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |

# TIME AND KNOT TABLE (concluded).

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour.

| Secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |
|-------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|---------|
| 40    | 22.500 | 16.364 | 12.857 | 10.588 | 9.000  | 7.826  | 6.923  | 6.207  | 5.625   | 5.143   | 4.737   | 4.390   | 4.091   |
| 41    | 22.360 | 16.290 | 12.811 | 10.557 | 8.978  | 7.803  | 6.910  | 6.196  | 5.616   | 5.136   | 4.731   | 4.385   | 4.086   |
| 42    | 22.222 | 16.216 | 12.766 | 10.526 | 8.955  | 7.792  | 6.897  | 6.186  | 5.607   | 5.128   | 4.724   | 4.379   | 4.082   |
| 43    | 22.086 | 16.143 | 12.721 | 10.496 | 8.933  | 7.775  | 6.883  | 6.175  | 5.599   | 5.121   | 4.718   | 4.374   | 4.077   |
| 44    | 21.951 | 16.071 | 12.676 | 10.465 | 8.911  | 7.759  | 6.870  | 6.164  | 5.590   | 5.114   | 4.712   | 4.369   | 4.072   |
| 45    | 21.818 | 16.000 | 12.632 | 10.435 | 8.889  | 7.742  | 6.857  | 6.154  | 5.581   | 5.106   | 4.706   | 4.364   | 4.068   |
| 46    | 21.687 | 15.929 | 12.587 | 10.405 | 8.867  | 7.725  | 6.844  | 6.143  | 5.573   | 5.099   | 4.700   | 4.358   | 4.063   |
| 47    | 21.557 | 15.859 | 12.544 | 10.375 | 8.845  | 7.709  | 6.831  | 6.133  | 5.564   | 5.092   | 4.693   | 4.353   | 4.059   |
| 48    | 21.429 | 15.789 | 12.500 | 10.345 | 8.824  | 7.692  | 6.818  | 6.122  | 5.556   | 5.085   | 4.687   | 4.348   | 4.054   |
| 49    | 21.302 | 15.721 | 12.457 | 10.315 | 8.802  | 7.676  | 6.805  | 6.112  | 5.547   | 5.078   | 4.681   | 4.343   | 4.049   |
| 50    | 21.176 | 15.652 | 12.414 | 10.286 | 8.780  | 7.660  | 6.792  | 6.102  | 5.538   | 5.070   | 4.675   | 4.337   | 4.045   |
| 51    | 21.053 | 15.584 | 12.371 | 10.256 | 8.759  | 7.643  | 6.780  | 6.091  | 5.530   | 5.063   | 4.669   | 4.332   | 4.040   |
| 52    | 20.930 | 15.517 | 12.329 | 10.227 | 8.738  | 7.627  | 6.767  | 6.081  | 5.521   | 5.056   | 4.663   | 4.327   | 4.035   |
| 53    | 20.809 | 15.451 | 12.287 | 10.198 | 8.717  | 7.611  | 6.754  | 6.071  | 5.513   | 5.049   | 4.657   | 4.322   | 4.031   |
| 54    | 20.690 | 15.385 | 12.245 | 10.169 | 8.696  | 7.595  | 6.742  | 6.061  | 5.505   | 5.042   | 4.651   | 4.316   | 4.027   |
| 55    | 20.571 | 15.319 | 12.203 | 10.141 | 8.675  | 7.579  | 6.729  | 6.050  | 5.496   | 5.035   | 4.645   | 4.311   | 4.022   |
| 56    | 20.455 | 15.254 | 12.162 | 10.112 | 8.654  | 7.563  | 6.716  | 6.040  | 5.488   | 5.028   | 4.639   | 4.306   | 4.018   |
| 57    | 20.339 | 15.190 | 12.121 | 10.084 | 8.633  | 7.547  | 6.704  | 6.030  | 5.479   | 5.021   | 4.633   | 4.301   | 4.013   |
| 58    | 20.225 | 15.126 | 12.081 | 10.056 | 8.612  | 7.531  | 6.691  | 6.020  | 5.471   | 5.014   | 4.627   | 4.296   | 4.009   |
| 59    | 20.112 | 15.063 | 12.040 | 10.028 | 8.592  | 7.516  | 6.679  | 6.010  | 5.463   | 5.007   | 4.621   | 4.291   | 4.004   |
| secs. | 2 min. | 3 min. | 4 min. | 5 min. | 6 min. | 7 min. | 8 min. | 9 min. | 10 min. | 11 min. | 12 min. | 13 min. | 14 min. |

TABLE OF  
COMPARISON OF ADMIRALTY KNOTS AND STATUTE MILES.

| Knots | Miles  | Knots | Miles   | Knots | Miles   | Knots | Miles   | Knots | Miles   |
|-------|--------|-------|---------|-------|---------|-------|---------|-------|---------|
| 1-00  | 1.1515 | 6-00  | 6.9091  | 11-00 | 12.6667 | 16-00 | 18.4242 | 21-00 | 24.1818 |
| 1-25  | 1.4394 | 6-25  | 7.1970  | 11-25 | 12.9545 | 16-25 | 18.7121 | 21-25 | 24.4697 |
| 1-50  | 1.7273 | 6-50  | 7.4848  | 11-50 | 13.2424 | 16-50 | 19.0000 | 21-50 | 24.7576 |
| 1-75  | 2.0152 | 6-75  | 7.7727  | 11-75 | 13.5303 | 16-75 | 19.2879 | 21-75 | 25.0455 |
| 2-00  | 2.3030 | 7-00  | 8.0606  | 12-00 | 13.8182 | 17-00 | 19.5758 | 22-00 | 25.3333 |
| 2-25  | 2.5909 | 7-25  | 8.3485  | 12-25 | 14.1061 | 17-25 | 19.8636 | 22-25 | 25.6212 |
| 2-50  | 2.8788 | 7-50  | 8.6364  | 12-50 | 14.3939 | 17-50 | 20.1515 | 22-50 | 25.9091 |
| 2-75  | 3.1667 | 7-75  | 8.9242  | 12-75 | 14.6818 | 17-75 | 20.4394 | 22-75 | 26.1970 |
| 3-00  | 3.4545 | 8-00  | 9.2121  | 13-00 | 14.9697 | 18-00 | 20.7273 | 23-00 | 26.4848 |
| 3-25  | 3.7424 | 8-25  | 9.5000  | 13-25 | 15.2576 | 18-25 | 21.0152 | 23-25 | 26.7727 |
| 3-50  | 4.0303 | 8-50  | 9.7879  | 13-50 | 15.5455 | 18-50 | 21.3030 | 23-50 | 27.0606 |
| 3-75  | 4.3182 | 8-75  | 10.0758 | 13-75 | 15.8333 | 18-75 | 21.5909 | 23-75 | 27.3485 |
| 4-00  | 4.6061 | 9-00  | 10.3636 | 14-00 | 16.1212 | 19-00 | 21.8788 | 24-00 | 27.6364 |
| 4-25  | 4.8939 | 9-25  | 10.6515 | 14-25 | 16.4091 | 19-25 | 22.1667 | 24-25 | 27.9242 |
| 4-50  | 5.1818 | 9-50  | 10.9394 | 14-50 | 16.6970 | 19-50 | 22.4545 | 24-50 | 28.2121 |
| 4-75  | 5.4697 | 9-75  | 11.2273 | 14-75 | 16.9848 | 19-75 | 22.7424 | 24-75 | 28.5000 |
| 5-00  | 5.7576 | 10-00 | 11.5152 | 15-00 | 17.2727 | 20-00 | 23.0303 | 25-00 | 28.7879 |
| 5-25  | 6.0455 | 10-25 | 11.8030 | 15-25 | 17.5606 | 20-25 | 23.3182 | 25-25 | 29.0758 |
| 5-50  | 6.3333 | 10-50 | 12.0909 | 15-50 | 17.8485 | 20-50 | 23.6061 | 25-50 | 29.3636 |
| 5-75  | 6.6212 | 10-75 | 12.3788 | 15-75 | 18.1364 | 20-75 | 23.8939 | 25-75 | 29.6515 |
| Miles | Knots  | Miles | Knots   | Miles | Knots   | Miles | Knots   | Miles | Knots   |
| 1-00  | 3.684  | 6-00  | 5.2105  | 11-00 | 9.5526  | 16-00 | 13.8947 | 21-00 | 18.2365 |
| 1-25  | 1.0855 | 6-25  | 5.4276  | 11-25 | 9.7697  | 16-25 | 14.1118 | 21-25 | 18.4539 |
| 1-50  | 1.9026 | 6-50  | 5.6447  | 11-50 | 9.9868  | 16-50 | 14.3289 | 21-50 | 18.6711 |
| 1-75  | 1.5197 | 6-75  | 5.8618  | 11-75 | 10.2039 | 16-75 | 14.5461 | 21-75 | 18.8882 |
| 2-00  | 1.7368 | 7-00  | 6.0789  | 12-00 | 10.4211 | 17-00 | 14.7632 | 22-00 | 19.1052 |
| 2-25  | 1.9539 | 7-25  | 6.2961  | 12-25 | 10.6382 | 17-25 | 14.9803 | 22-25 | 19.3224 |
| 2-50  | 2.1711 | 7-50  | 6.5132  | 12-50 | 10.8553 | 17-50 | 15.1974 | 22-50 | 19.5395 |
| 2-75  | 2.3882 | 7-75  | 6.7303  | 12-75 | 11.0724 | 17-75 | 15.4145 | 22-75 | 19.7566 |
| 3-00  | 2.6053 | 8-00  | 6.9474  | 13-00 | 11.2895 | 18-00 | 15.6316 | 23-00 | 19.9737 |
| 3-25  | 2.8224 | 8-25  | 7.1645  | 13-25 | 11.5066 | 18-25 | 15.8487 | 23-25 | 20.1908 |
| 3-50  | 3.0395 | 8-50  | 7.3816  | 13-50 | 11.7237 | 18-50 | 16.0658 | 23-50 | 20.4079 |
| 3-75  | 3.2566 | 8-75  | 7.5987  | 13-75 | 11.9408 | 18-75 | 16.2829 | 23-75 | 20.6250 |
| 4-00  | 3.4737 | 9-00  | 7.8158  | 14-00 | 12.1579 | 19-00 | 16.5000 | 24-00 | 20.8421 |
| 4-25  | 3.6908 | 9-25  | 8.0329  | 14-25 | 12.3750 | 19-25 | 16.7171 | 24-25 | 21.0592 |
| 4-50  | 3.9079 | 9-50  | 8.2500  | 14-50 | 12.5921 | 19-50 | 16.9342 | 24-50 | 21.2763 |
| 4-75  | 4.1250 | 9-75  | 8.4671  | 14-75 | 12.8092 | 19-75 | 17.1513 | 24-75 | 21.4934 |
| 5-00  | 4.3421 | 10-00 | 8.6842  | 15-00 | 13.0263 | 20-00 | 17.3684 | 25-00 | 21.7105 |
| 5-25  | 4.5592 | 10-25 | 8.9013  | 15-25 | 13.2434 | 20-25 | 17.5855 | 25-25 | 21.9276 |
| 5-50  | 4.7763 | 10-50 | 9.1184  | 15-50 | 13.4605 | 20-50 | 17.8026 | 25-50 | 22.1447 |
| 5-75  | 4.9934 | 10-75 | 9.3355  | 15-75 | 13.6776 | 20-75 | 18.0197 | 25-75 | 22.3618 |

N.B. The Admiralty knot = 6,080 ft.; 1 statute mile = 5,280 ft.

TABLE OF KILOMETRES TO ADMIRALTY KNOTS AND ADMIRALTY KNOTS TO KILOMETRES.

| Kilos. | Knots  | Kilos. | Knots  | Kilos. | Knots  | Kilos. | Knots  | Kilos. | Knots  |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 1.0    | .540   | 8.0    | 4.317  | 15.0   | 8.094  | 22.0   | 11.872 | 29.0   | 15.649 |
| 1.25   | .675   | 8.25   | 4.452  | 15.25  | 8.229  | 22.25  | 12.006 | 29.25  | 15.784 |
| 1.5    | .809   | 8.5    | 4.587  | 15.5   | 8.364  | 22.5   | 12.141 | 29.5   | 15.919 |
| 1.75   | .944   | 8.75   | 4.722  | 15.75  | 8.499  | 22.75  | 12.276 | 29.75  | 16.054 |
| 2.0    | 1.079  | 9.0    | 4.857  | 16.0   | 8.634  | 23.0   | 12.411 | 30.0   | 16.188 |
| 2.25   | 1.214  | 9.25   | 4.991  | 16.25  | 8.769  | 23.25  | 12.546 | 30.25  | 16.323 |
| 2.5    | 1.349  | 9.5    | 5.126  | 16.5   | 8.904  | 23.5   | 12.681 | 30.5   | 16.458 |
| 2.75   | 1.484  | 9.75   | 5.261  | 16.75  | 9.039  | 23.75  | 12.816 | 30.75  | 16.593 |
| 3.0    | 1.619  | 10.0   | 5.396  | 17.0   | 9.173  | 24.0   | 12.951 | 31.0   | 16.728 |
| 3.25   | 1.754  | 10.25  | 5.531  | 17.25  | 9.308  | 24.25  | 13.086 | 31.25  | 16.863 |
| 3.5    | 1.889  | 10.5   | 5.666  | 17.5   | 9.443  | 24.5   | 13.221 | 31.5   | 16.998 |
| 3.75   | 2.024  | 10.75  | 5.801  | 17.75  | 9.578  | 24.75  | 13.356 | 31.75  | 17.133 |
| 4.0    | 2.158  | 11.0   | 5.936  | 18.0   | 9.713  | 25.0   | 13.490 | 32.0   | 17.268 |
| 4.25   | 2.293  | 11.25  | 6.071  | 18.25  | 9.848  | 25.25  | 13.625 | 32.25  | 17.403 |
| 4.5    | 2.428  | 11.5   | 6.206  | 18.5   | 9.983  | 25.5   | 13.760 | 32.5   | 17.538 |
| 4.75   | 2.563  | 11.75  | 6.340  | 18.75  | 10.118 | 25.75  | 13.895 | 32.75  | 17.672 |
| 5.0    | 2.698  | 12.0   | 6.475  | 19.0   | 10.253 | 26.0   | 14.030 | 33.0   | 17.807 |
| 5.25   | 2.833  | 12.25  | 6.610  | 19.25  | 10.388 | 26.25  | 14.165 | 33.25  | 17.942 |
| 5.5    | 2.968  | 12.5   | 6.745  | 19.5   | 10.523 | 26.5   | 14.300 | 33.5   | 18.077 |
| 5.75   | 3.103  | 12.75  | 6.880  | 19.75  | 10.657 | 26.75  | 14.435 | 33.75  | 18.212 |
| 6.0    | 3.238  | 13.0   | 7.015  | 20.0   | 10.792 | 27.0   | 14.570 | 34.0   | 18.347 |
| 6.25   | 3.373  | 13.25  | 7.150  | 20.25  | 10.927 | 27.25  | 14.705 | 34.25  | 18.482 |
| 6.5    | 3.508  | 13.5   | 7.285  | 20.5   | 11.062 | 27.5   | 14.839 | 34.5   | 18.617 |
| 6.75   | 3.642  | 13.75  | 7.420  | 20.75  | 11.197 | 27.75  | 14.974 | 34.75  | 18.752 |
| 7.0    | 3.777  | 14.0   | 7.555  | 21.0   | 11.332 | 28.0   | 15.109 | 35.00  | 18.887 |
| 7.25   | 3.912  | 14.25  | 7.690  | 21.25  | 11.467 | 28.25  | 15.244 | 35.25  | 19.021 |
| 7.5    | 4.047  | 14.5   | 7.824  | 21.5   | 11.602 | 28.5   | 15.379 | 35.5   | 19.156 |
| 7.75   | 4.182  | 14.75  | 7.959  | 21.75  | 11.737 | 28.75  | 15.514 | 35.75  | 19.291 |
| Knots  | Kilos. | Knots  | Kilos. | Knots  | Kilos. | Knots  | Kilos. | Knots  | Kilos. |
| 1.0    | 1.853  | 4.75   | 8.803  | 8.5    | 15.752 | 12.25  | 22.701 | 16.0   | 29.651 |
| 1.25   | 2.316  | 5.0    | 9.266  | 8.75   | 16.215 | 12.5   | 23.165 | 16.25  | 30.114 |
| 1.5    | 2.780  | 5.25   | 9.729  | 9.0    | 16.679 | 12.75  | 23.628 | 16.5   | 30.577 |
| 1.75   | 3.243  | 5.5    | 10.192 | 9.25   | 17.142 | 13.0   | 24.091 | 16.75  | 31.041 |
| 2.0    | 3.706  | 5.75   | 10.656 | 9.5    | 17.605 | 13.25  | 24.554 | 17.0   | 31.504 |
| 2.25   | 4.170  | 6.0    | 11.119 | 9.75   | 18.068 | 13.5   | 25.018 | 17.25  | 31.967 |
| 2.5    | 4.633  | 6.25   | 11.582 | 10.0   | 18.532 | 13.75  | 25.481 | 17.5   | 32.430 |
| 2.75   | 5.096  | 6.5    | 12.046 | 10.25  | 18.995 | 14.0   | 25.944 | 17.75  | 32.894 |
| 3.0    | 5.560  | 6.75   | 12.509 | 10.5   | 19.458 | 14.25  | 26.408 | 18.0   | 33.357 |
| 3.25   | 6.023  | 7.0    | 12.972 | 10.75  | 19.922 | 14.5   | 26.871 | 18.25  | 33.820 |
| 3.5    | 6.486  | 7.25   | 13.435 | 11.0   | 20.385 | 14.75  | 27.334 | 18.5   | 34.284 |
| 3.75   | 6.949  | 7.5    | 13.899 | 11.25  | 20.848 | 15.0   | 27.798 | 18.75  | 34.747 |
| 4.0    | 7.413  | 7.75   | 14.362 | 11.5   | 21.311 | 15.25  | 28.261 | 19.0   | 35.210 |
| 4.25   | 7.876  | 8.0    | 14.825 | 11.75  | 21.775 | 15.5   | 28.724 | 19.25  | 35.673 |
| 4.5    | 8.339  | 8.25   | 15.289 | 12.0   | 22.238 | 15.75  | 29.187 | 19.5   | 36.137 |

TABLE OF DISTANCES DOWN THE COURSE OF THE RIVER THAMES IN NAUTICAL MILES.

*Note.*—The nautical mile given in this table is the Admiralty knot of 6,080 linear feet.

| London Bridge | Deptford Dockyard Basin | Deptford Dockyard | Greenwich, West of College | Blackwall Pier, East End | Woolwich, Roff's Wharf | Barking Creek | Half-way House | Bainham Creek | Erith Pier | Furdeet | Greenhithe Pier | Grays Pier | Gravesend Town Pier | Oven's Buoy | Hope Point | Shell Haven House | Yardlett Buoy | Abreast of Southend Pier | Nore Light |
|---------------|-------------------------|-------------------|----------------------------|--------------------------|------------------------|---------------|----------------|---------------|------------|---------|-----------------|------------|---------------------|-------------|------------|-------------------|---------------|--------------------------|------------|
| 8.45          | 8.45                    | 2.22              | 1.52                       | 2.33                     | 1.70                   | 1.30          | 1.70           | 1.20          | 1.70       | 4.35    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 5.15          | 5.15                    | 2.22              | 4.25                       | 4.33                     | 3.00                   | 2.00          | 2.00           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 6.77          | 6.77                    | 4.95              | 5.95                       | 5.03                     | 3.70                   | 2.30          | 2.30           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 8.40          | 8.40                    | 6.65              | 7.25                       | 6.33                     | 4.40                   | 3.00          | 3.00           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 10.10         | 10.10                   | 7.95              | 8.25                       | 7.33                     | 5.10                   | 3.70          | 3.70           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 11.40         | 11.40                   | 9.25              | 9.25                       | 8.33                     | 5.80                   | 4.40          | 4.40           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 13.10         | 13.10                   | 10.55             | 10.15                      | 9.23                     | 6.50                   | 5.10          | 5.10           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 14.30         | 14.30                   | 11.85             | 11.25                      | 10.33                    | 7.20                   | 5.80          | 5.80           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 16.00         | 16.00                   | 13.15             | 12.45                      | 11.53                    | 7.90                   | 6.50          | 6.50           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 18.60         | 18.60                   | 15.15             | 14.45                      | 13.53                    | 9.00                   | 7.60          | 7.60           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 20.40         | 20.40                   | 16.05             | 15.25                      | 14.63                    | 10.00                  | 8.30          | 8.30           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 22.95         | 22.95                   | 18.50             | 17.60                      | 16.13                    | 11.30                  | 9.60          | 9.60           | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 25.80         | 25.80                   | 21.35             | 20.25                      | 18.13                    | 12.60                  | 10.90         | 10.90          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 27.55         | 27.55                   | 24.10             | 22.40                      | 20.43                    | 13.90                  | 12.20         | 12.20          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 30.10         | 30.10                   | 26.65             | 25.35                      | 22.93                    | 15.20                  | 13.50         | 13.50          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 33.00         | 33.00                   | 29.55             | 28.05                      | 25.43                    | 16.50                  | 14.80         | 14.80          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 37.90         | 37.90                   | 34.45             | 32.75                      | 28.13                    | 17.80                  | 16.10         | 16.10          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 41.80         | 41.80                   | 38.35             | 36.45                      | 30.63                    | 19.10                  | 17.40         | 17.40          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 45.80         | 45.80                   | 42.35             | 40.45                      | 33.13                    | 20.40                  | 18.70         | 18.70          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 49.80         | 49.80                   | 46.35             | 44.45                      | 35.63                    | 21.70                  | 19.90         | 19.90          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 53.80         | 53.80                   | 50.35             | 48.45                      | 38.13                    | 23.00                  | 21.20         | 21.20          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 57.80         | 57.80                   | 54.35             | 52.45                      | 40.63                    | 24.30                  | 22.50         | 22.50          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 61.80         | 61.80                   | 58.35             | 56.45                      | 43.13                    | 25.60                  | 23.80         | 23.80          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 65.80         | 65.80                   | 62.35             | 60.45                      | 45.63                    | 26.90                  | 25.10         | 25.10          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 69.80         | 69.80                   | 66.35             | 64.45                      | 48.13                    | 28.20                  | 26.40         | 26.40          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 73.80         | 73.80                   | 70.35             | 68.45                      | 50.63                    | 29.50                  | 27.70         | 27.70          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 77.80         | 77.80                   | 74.35             | 72.45                      | 53.13                    | 30.80                  | 29.00         | 29.00          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 81.80         | 81.80                   | 78.35             | 76.45                      | 55.63                    | 32.10                  | 30.30         | 30.30          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 85.80         | 85.80                   | 82.35             | 80.45                      | 58.13                    | 33.40                  | 31.60         | 31.60          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 89.80         | 89.80                   | 86.35             | 84.45                      | 60.63                    | 34.70                  | 32.90         | 32.90          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 93.80         | 93.80                   | 90.35             | 88.45                      | 63.13                    | 36.00                  | 34.20         | 34.20          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 97.80         | 97.80                   | 94.35             | 92.45                      | 65.63                    | 37.30                  | 35.50         | 35.50          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 101.80        | 101.80                  | 98.35             | 96.45                      | 68.13                    | 38.60                  | 36.80         | 36.80          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 105.80        | 105.80                  | 102.35            | 100.45                     | 70.63                    | 39.90                  | 38.10         | 38.10          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 109.80        | 109.80                  | 106.35            | 104.45                     | 73.13                    | 41.20                  | 39.40         | 39.40          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 113.80        | 113.80                  | 110.35            | 108.45                     | 75.63                    | 42.50                  | 40.70         | 40.70          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 117.80        | 117.80                  | 114.35            | 112.45                     | 78.13                    | 43.80                  | 42.00         | 42.00          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 121.80        | 121.80                  | 118.35            | 116.45                     | 80.63                    | 45.10                  | 43.30         | 43.30          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 125.80        | 125.80                  | 122.35            | 120.45                     | 83.13                    | 46.40                  | 44.60         | 44.60          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 129.80        | 129.80                  | 126.35            | 124.45                     | 85.63                    | 47.70                  | 45.90         | 45.90          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 133.80        | 133.80                  | 130.35            | 128.45                     | 88.13                    | 49.00                  | 47.20         | 47.20          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 137.80        | 137.80                  | 134.35            | 132.45                     | 90.63                    | 50.30                  | 48.50         | 48.50          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 141.80        | 141.80                  | 138.35            | 136.45                     | 93.13                    | 51.60                  | 49.80         | 49.80          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 145.80        | 145.80                  | 142.35            | 140.45                     | 95.63                    | 52.90                  | 51.10         | 51.10          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 149.80        | 149.80                  | 146.35            | 144.45                     | 98.13                    | 54.20                  | 52.40         | 52.40          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 153.80        | 153.80                  | 150.35            | 148.45                     | 100.63                   | 55.50                  | 53.70         | 53.70          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 157.80        | 157.80                  | 154.35            | 152.45                     | 103.13                   | 56.80                  | 55.00         | 55.00          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 161.80        | 161.80                  | 158.35            | 156.45                     | 105.63                   | 58.10                  | 56.30         | 56.30          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 165.80        | 165.80                  | 162.35            | 160.45                     | 108.13                   | 59.40                  | 57.60         | 57.60          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 169.80        | 169.80                  | 166.35            | 164.45                     | 110.63                   | 60.70                  | 58.90         | 58.90          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 173.80        | 173.80                  | 170.35            | 168.45                     | 113.13                   | 62.00                  | 60.20         | 60.20          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 177.80        | 177.80                  | 174.35            | 172.45                     | 115.63                   | 63.30                  | 61.50         | 61.50          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 181.80        | 181.80                  | 178.35            | 176.45                     | 118.13                   | 64.60                  | 62.80         | 62.80          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 185.80        | 185.80                  | 182.35            | 180.45                     | 120.63                   | 65.90                  | 64.10         | 64.10          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 189.80        | 189.80                  | 186.35            | 184.45                     | 123.13                   | 67.20                  | 65.40         | 65.40          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 193.80        | 193.80                  | 190.35            | 188.45                     | 125.63                   | 68.50                  | 66.70         | 66.70          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 197.80        | 197.80                  | 194.35            | 192.45                     | 128.13                   | 69.80                  | 68.00         | 68.00          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 201.80        | 201.80                  | 198.35            | 196.45                     | 130.63                   | 71.10                  | 69.30         | 69.30          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 205.80        | 205.80                  | 202.35            | 200.45                     | 133.13                   | 72.40                  | 70.60         | 70.60          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 209.80        | 209.80                  | 206.35            | 204.45                     | 135.63                   | 73.70                  | 71.90         | 71.90          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 213.80        | 213.80                  | 210.35            | 208.45                     | 138.13                   | 75.00                  | 73.20         | 73.20          | 1.20          | 4.35       | 2.86    | 1.80            | 3.40       | 2.86                | 1.71        | 2.45       | 4.30              | 2.30          | 8.40                     | 7.30       |
| 217.80        | 217.80                  | 214.35            | 212.45                     | 140.63                   | 76.30                  | 74.50         |                |               |            |         |                 |            |                     |             |            |                   |               |                          |            |





TABLE OF DISTANCES FROM CARLISLE BRIDGE TO ROCK-A-BILL LIGHT, AND FROM CARLISLE  
BRIDGE TO WICKLOW HEAD, IN NAUTICAL MILES.

| Carlisle Bridge                                 | Carlisle Bridge | North Wall Light | Pool Beg Light | Bailey Light | Howth Harbour Light | Kingstown, E. Pier | Kish Light-vessel |
|---|-----------------|------------------|----------------|--------------|---------------------|--------------------|-------------------|
| North Wall Light . . . . .                      | 1·17            |                  |                |              |                     |                    |                   |
| Pool Beg Light . . . . .                        | 3·97            | 2·80             |                |              |                     |                    |                   |
| Bailey Light . . . . .                          | 7·77            | 6·60             | 3·80           |              |                     |                    |                   |
| Howth Harbour Light . . . . .                   | 10·57           | 9·40             | 6·60           | 2·80         |                     |                    |                   |
| Rock-a-Bill Light . . . . .                     | 22·77           | 21·60            | 18·80          | 15·00        | 13·20               |                    |                   |
| Kingstown, E. Pier . . . . .                    | 6·67            | 5·50             | 2·70           | 4·50         | —                   |                    |                   |
| Kish Light-vessel . . . . .                     | 13·32           | 12·15            | 9·35           | 5·00         | —                   | 6·65               |                   |
| Wicklow Head . . . . .                          | 34·32           | 33·15            | 30·35          | —            | —                   | 27·65              |                   |
| Wicklow Head, 2 lights in one, distance 1½ mile | 28·17           | 27·00            | 24·20          | 23·92        | —                   | 21·50              | 21 00             |

The distance from Kingstown (E. Pier) to Holyhead is 56 knots, or 64·48 statute miles.  
*Note.*—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

TABLE OF DISTANCES FROM CUMBERLAND BASIN DOWN THE BRISTOL CHANNEL IN NAUTICAL MILES.

| Cumberland Basin                             | Lamplighter Slip | King Road, Black Buoy | Portishead Point | Lightship on Welsh and English Grounds | Lightship on Flat Holmes | Black and White Striped Buoy at Breaksea Point | Nash Point, bearing 1 mile N. by E. | West Helwick Sand Light-vessel |
|--|------------------|-----------------------|------------------|--|--------------------------|--|-------------------------------------|--------------------------------|
| Lamplighter Slip                             | 4.0              |                       |                  |  |                          |  |                                     |                                |
| King Road, Black Buoy                        | 6.4              | 2.4                   |                  |  |                          |  |                                     |                                |
| Portishead Point                             | 8.4              | 4.4                   | 2.0              |  |                          |  |                                     |                                |
| Lightship on Welsh and English Grounds       | 16.0             | 12.0                  | 9.6              | 7.6                                    |                          |  |                                     |                                |
| Lightship on Flat Holmes                     | 22.8             | 18.8                  | 16.4             | 14.4                                   | 6.8                      |  |                                     |                                |
| Foreland Point                               | 49.6             | 45.6                  | 43.2             | 41.2                                   | 33.6                     |  |                                     |                                |
| Ilfracombe                                   | 62.0             | 58.0                  | 55.6             | 53.6                                   | 46.0                     |  |                                     |                                |
| Black and White Striped Buoy at Breaksea Pt. | 33.9             | 29.9                  | 27.5             | 25.5                                   | 17.9                     | 11.1   |                                     |                                |
| Nash Point, bearing 1 mile N. by E.          | 39.5             | 35.5                  | 33.1             | 31.1                                   | 23.5                     | 16.7   | 9.6                                 |                                |
| West Helwick Sand Light-vessel               | 71.7             | 67.7                  | 65.3             | 63.3                                   | 55.7                     | 48.9   | 37.8                                | 32.2                           |
| St. Ann's Head Lighthouse                    | 103.7            | 99.7                  | 97.3             | 95.3                                   | 87.7                     | 80.9   | 69.8                                | 64.2                           |
|  |                  |                       |                  |  |                          |  |                                     | 32.0                           |

West Helwick Sand Light-vessel

Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

TABLE OF DISTANCES FROM ROCK FERRY, LIVERPOOL, TO HOLYHEAD BREAKWATER IN NAUTICAL MILES.

| Liverpool, Rock Ferry            |       | Rock Lighthouse |       | Crosby Lightship |       | Formby Lightship |       | Bell Beacon |       | North-west Lightship |      | North Toe, Great Orme's Head |  | Point Lynas |  | Skerries |  |
|----------------------------------|-------|-----------------|-------|------------------|-------|------------------|-------|-------------|-------|----------------------|------|------------------------------|--|-------------|--|----------|--|
| Rock Lighthouse, No. 5, Red Buoy | 4.40  |                 | 4.80  | 2.60             | 2.30  | 26.62            | 22.00 | 15.80       | 12.00 | 17.60                | 5.60 |                              |  |             |  |          |  |
| Crosby Lightship                 | 9.20  |                 | 7.40  | 4.90             | 6.92  | 22.42            | 37.80 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| Formby Lightship                 | 11.80 |                 | 9.70  | 31.52            | 29.92 | 41.12            | 36.50 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| Bell Beacon                      | 14.10 |                 | 14.32 | 47.32            | 44.72 | 53.12            | 48.50 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| North-west Lightship             | 18.72 |                 | 36.32 | 46.02            | 43.42 | 58.02            | 54.10 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| North Toe, Great Orme's Head     | 40.72 |                 | 52.12 | 50.82            | 55.42 | 61.02            | 58.72 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| Point Lynas                      | 56.52 |                 | 62.82 | 63.62            | 67.22 | 72.82            | 72.82 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| Point Lynas                      | 55.22 |                 | 67.22 | 68.42            | 72.82 | 72.82            | 72.82 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| Skerries                         | 67.22 |                 | 72.82 | 72.82            | 72.82 | 72.82            | 72.82 | —           | —     | —                    | —    |                              |  |             |  |          |  |
| Holyhead Breakwater Light        | 72.82 |                 | 72.82 | 72.82            | 72.82 | 72.82            | 72.82 | —           | —     | —                    | —    |                              |  |             |  |          |  |

*Note.*—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

TABLE OF DISTANCES DOWN THE CENTRE OF THE RIVER TYNE IN NAUTICAL MILES.

*Note.*—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

| Tyne Bridge | Tyne Main Spout | Friar's Goose Point | St. Anthony's Point | Bill Point | Hebburn Quay Road at Leslie's Building Yard | WallSEND Ironworks | Howdon Landing, opposite Palmer's Iron Ship-building Yard | Northumberland Dock Entrance | Jarrow Dock Entrance, opposite side | Whitehill Point, North side | Mill Dam Landing-place, South Shields | New Quay Landing-place, North Shields | Low Lighthouse, North Shields | Tynemouth Bar |
|-------------|-----------------|---------------------|---------------------|------------|---|--------------------|---|------------------------------|-------------------------------------|-----------------------------|---------------------------------------|---------------------------------------|-------------------------------|---------------|
|             | 1-44            | 35                  | 1-21                | 1-26       | 1-50  | 1-82               | 1-80  | 3-38                         | 4-10                                | 4-63                        | 5-10                                  | 5-50                                  | 6-10                          | 6-26          |
|             | 2-20            | 1-21                | 1-26                | 1-50       | 1-82  | 1-80               | 3-38  | 4-10                         | 4-63                                | 5-10                        | 5-50                                  | 6-10                                  | 6-26                          | 6-42          |
|             | 2-70            | 1-61                | 1-26                | 1-50       | 1-82  | 1-80               | 3-38  | 4-10                         | 4-63                                | 5-10                        | 5-50                                  | 6-10                                  | 6-26                          | 6-42          |
|             | 4-02            | 2-93                | 2-58                | 1-82       | 1-82  | 1-80               | 3-38  | 4-10                         | 4-63                                | 5-10                        | 5-50                                  | 6-10                                  | 6-26                          | 6-42          |
|             | 4-50            | 3-41                | 3-06                | 2-30       | 2-30  | 1-80               | 3-38  | 4-10                         | 4-63                                | 5-10                        | 5-50                                  | 6-10                                  | 6-26                          | 6-42          |
|             | 5-43            | 4-34                | 3-99                | 3-23       | 3-23  | 2-73               | 1-41  | 2-06                         | 2-78                                | 3-01                        | 3-31                                  | 3-78                                  | 4-18                          | 4-46          |
|             | 6-08            | 4-99                | 4-64                | 3-88       | 3-88  | 3-38               | 2-06  | 2-78                         | 3-01                                | 3-31                        | 3-78                                  | 4-18                                  | 4-46                          | 4-74          |
|             | 6-80            | 5-71                | 5-36                | 4-60       | 4-60  | 4-10               | 2-78  | 3-01                         | 3-31                                | 3-78                        | 4-18                                  | 4-46                                  | 4-74                          | 5-02          |
|             | 7-03            | 5-94                | 5-59                | 4-83       | 4-83  | 4-33               | 3-01  | 3-31                         | 3-78                                | 4-18                        | 4-46                                  | 4-74                                  | 5-02                          | 5-30          |
|             | 7-33            | 6-24                | 5-89                | 5-13       | 5-13  | 4-63               | 3-31  | 3-78                         | 4-18                                | 4-46                        | 4-74                                  | 5-02                                  | 5-30                          | 5-58          |
|             | 7-80            | 6-71                | 6-36                | 5-60       | 5-60  | 5-10               | 3-78  | 4-18                         | 4-46                                | 4-74                        | 5-02                                  | 5-30                                  | 5-58                          | 5-86          |
|             | 8-20            | 7-11                | 6-76                | 6-00       | 6-00  | 5-50               | 4-18  | 4-46                         | 4-74                                | 5-02                        | 5-30                                  | 5-58                                  | 5-86                          | 6-14          |
|             | 8-96            | 7-87                | 7-52                | 6-76       | 6-76  | 6-26               | 4-94  | 4-46                         | 4-74                                | 5-02                        | 5-30                                  | 5-58                                  | 5-86                          | 6-14          |

The distance from Tynemouth Bar to New Biggen Point is 13 32 statute miles, or 11-57 knots.

|   |      |
|---|------|
| Howdon Landing, opposite Palmer's Iron Ship-building Yard | 1-55 |
| Northumberland Dock Entrance                              | 1-72 |
| Jarrow Dock Entrance, opposite side                       | 1-90 |
| Whitehill Point, North side                               | 2-37 |
| Mill Dam Landing-place, South Shields                     | 2-77 |
| New Quay Landing-place, North Shields                     | 3-63 |
| Low Lighthouse, North Shields                             | 4-46 |

TABLE OF DISTANCES DOWN THE RIVER HUMBER, BY SHIP'S CHANNEL COURSE, FROM HULL  
ROADS TO SEA IN NAUTICAL MILES.

| Hull Roads, Citadel bearing N.                              | Hebble's Float | No. 7, Red Buoy | No. 10, Black Buoy | No. 9, Black Buoy | No. 8, Black Buoy | No. 6, Black Buoy | No. 3, Chequered Buoy | No. 3, Red Buoy | Bull Float | No. 1, Chequered Buoy |
|---|----------------|-----------------|--------------------|-------------------|-------------------|-------------------|-----------------------|-----------------|------------|-----------------------|
| Hebble's Float  | 1.51           | 2.18            |                    |                   |                   |                   |                       |                 |            | 1.73                  |
| No. 7, Red Buoy, or Paul Lighthouse, N.E. by E.             | 3.69           |                 |                    |                   |                   |                   |                       |                 |            |                       |
| No. 10, Black Buoy  | 6.08           | 4.57            | 2.39               |                   |                   |                   |                       |                 |            |                       |
| No. 9, Black Buoy, or Killingholme High Light, W. by S.     | 7.38           | 5.87            | 3.69               | 1.30              |                   |                   |                       |                 |            |                       |
| No. 8, Black Buoy   | 9.12           | 7.61            | 5.43               | 3.04              | 1.74              |                   |                       |                 |            |                       |
| No. 6, Black Buoy   | 11.51          | 10.00           | 7.82               | 5.43              | 4.13              | 2.39              |                       |                 |            |                       |
| No. 3, Chequered Buoy, or Grimsby Hydraulic Tower, W. by S. | 14.54          | 13.03           | 10.85              | 8.46              | 7.16              | 5.42              | 3.03                  |                 |            |                       |
| No. 3, Red Buoy   | 16.72          | 15.21           | 13.03              | 10.64             | 9.34              | 7.60              | 5.21                  | 2.18            |            |                       |
| Bull Float, or Spurn High Light, E.N.E.                     | 19.32          | 17.81           | 15.63              | 13.24             | 11.94             | 10.20             | 7.81                  | 4.78            | 2.60       |                       |
| No. 1, Chequered Buoy                                       | 21.93          | 20.42           | 18.24              | 15.85             | 14.55             | 12.81             | 10.42                 | 7.39            | 5.21       | 6.21                  |
| Newsand Float, N.E.   | 23.66          | 22.15           | 19.97              | 17.58             | 16.28             | 14.54             | 12.15                 | 9.12            | 6.94       | 4.34                  |

The distance between No. 8, Black Buoy, and Spurn High Light, E.N.E. 1 mile, is 10.2 knots, or 11.5 statute miles.

*Note.*—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.



TABLE OF DISTANCES FROM SOUTHAMPTON ROUND THE ISLE OF WIGHT THROUGH THE ST. HELEN'S PASSAGE, AND BACK TO SOUTHAMPTON THROUGH THE NEEDLES PASSAGE, IN NAUTICAL MILES.

| Southampton Dock Entrance                              |      |      |      |      |      |      |  |  |  |  |  |  |  |                 |
|--|------|------|------|------|------|------|--|--|--|--|--|--|--|-----------------|
| Weston Red Buoy  | 1.2  |      |      |      |      |      |  |  |  |  |  |  |  | Weston Red Buoy |
| Netley Hospital, East End                              | 2.8  |      |      |      |      |      |  |  |  |  |  |  |  | Calshot         |
| Calshot Light  | 6.8  |      |      |      |      |      |  |  |  |  |  |  |  | Calshot         |
| Measured Mile, West Posts in 1, distance 6 mile        | 11.7 | 10.5 | 8.9  | 4.9  |      |      |  |  |  |  |  |  |  |                 |
| Gullicker Point, East Posts in 1, distance 6 mile      | 12.7 | 11.5 | 9.9  | 5.9  |      |      |  |  |  |  |  |  |  |                 |
| Warner Light   | 16.3 | 15.1 | 13.5 | 6.5  |      |      |  |  |  |  |  |  |  |                 |
| Warner Light   | 16.2 | 15.0 | 13.4 | 9.4  |      |      |  |  |  |  |  |  |  |                 |
| Nab Light  | 18.8 | 17.6 | 16.0 | 12.0 | 2.6  |      |  |  |  |  |  |  |  |                 |
| Bonchurch, distant 1 mile N. by W.                     | 27.2 | 26.0 | 24.4 | 20.4 | 11.0 | 8.4  |  |  |  |  |  |  |  |                 |
| St. Catharine's Point, distant 1 mile N.N.E.           | 32.3 | 31.1 | 29.5 | 25.5 | 16.1 | 13.5 |  |  |  |  |  |  |  |                 |
| Needles Light, dist. 8 m. E. by S. (Hurst Lights in 1) | 45.7 | 44.5 | 42.9 | 38.9 | 29.6 | 26.9 |  |  |  |  |  |  |  |                 |
| Hurst Castle High Light                                | 49.4 | 48.2 | 46.6 | 42.6 | 33.2 | 30.6 |  |  |  |  |  |  |  |                 |
| Calshot  | 61.4 | 60.2 | 58.6 | 54.6 | 45.2 | 42.6 |  |  |  |  |  |  |  |                 |
| Weston Red Buoy  | 67.0 | 65.8 | 64.2 | 60.2 | 50.8 | 48.2 |  |  |  |  |  |  |  |                 |
| Southampton Docks                                      | 68.2 | 67.0 | 65.4 | 61.4 | 52.0 | 49.4 |  |  |  |  |  |  |  |                 |





## STEERING.

TURNING MOMENT OF RUDDER. (*Barnes.*)

$M$  = turning moment of rudder in foot lbs. [axis in foot lbs.

$m$  = moment of pressure of water on rudder relatively to its

$D$  = distance of centre of gravity of ship from centre of gravity of rudder surface in feet, measured along the middle line of ship. [axis of rudder in feet.

$d$  = distance of centre of gravity of rudder surface from

$V$  = velocity of current past rudder in knots per hour.

$A$  = area of rudder surface in square feet.

$P$  = normal pressure on rudder in lbs. [rudder.

$L$  = longitudinal component of  $P$  = direct head resistance of

$T$  = lateral component of  $P$  tending to turn ship.

$\theta$  = angle rudder makes with middle line of ship.

$C$  = constant = 2.85235.

$M = A \cdot C \cdot V^2 \cdot \sin^2 \theta \cdot \cos \theta.$   $L = A \cdot C \cdot V^2 \cdot \sin^3 \theta.$

$m = A \cdot C \cdot V^2 \cdot d \cdot \sin^2 \theta.$   $T = A \cdot C \cdot V^2 \cdot \sin^2 \theta \cdot \cos \theta.$

$P = A \cdot C \cdot V^2 \cdot \sin^2 \theta.$

*Note.*—In the above formulæ it will be seen that the pressure has been taken to vary as the square of the velocity, but experiment shows that when the speeds vary as 1 : 2 : 3 : 4 the pressures vary as 1 : 3 : 6.5 : 8.5, instead of 1<sup>2</sup> : 2<sup>2</sup> : 3<sup>2</sup> : 4<sup>2</sup>.

## BEST BREADTH OF RUDDER.

The best breadth of rudder for a ship when moving at a given speed is that which allows it to be put over to an angle of 45° from the middle line of the ship.

TABLE OF THE PROPORTION OF RUDDER SURFACE TO AREA OF LONGITUDINAL IMMERSSED SECTION IN SOME OF H.M. SCREW SHIPS.

| Name of Ship | Area of Rudder in Square Feet | Area of Longitudinal Vertical Section in Square Feet | Area of Section Divided by Area of Rudder | Name of Ship | Area of Rudder in Square Feet | Area of Longitudinal Vertical Section in Square Feet | Area of Section Divided by Area of Rudder |
|--------------|-------------------------------|--|---|--------------|-------------------------------|--|---|
| Achilles     | 166                           | 9792   | 59.0                                      | Glatton      | 163                           | 4579   | 28.0                                      |
| Arethusa     | 114                           | 6369   | 47.0                                      | Inconstant   | 191                           | 7640   | 40.0                                      |
| Bellerophon  | 248                           | 7301   | 29.4                                      | Minotaur     | 198                           | 10367  | 52.4                                      |
| Blonde       | 203                           | 7455   | 36.7                                      | Monarch      | 231                           | 7653   | 33.1                                      |
| Canopus      | 127                           | 4592   | 36.1                                      | Raleigh      | 109                           | 3854   | 35.3                                      |
| Cyclops      | 95                            | 3613   | 38.1                                      | Shah         | 203                           | 7455   | 36.7                                      |
| Devastation  | 165                           | 7615   | 46.1                                      | Warrior      | 180                           | 9271   | 51.5                                      |

**OPTICAL METHOD OF MEASURING THE CIRCLE DESCRIBED BY A SHIP. (F. Martin, M.I.N.A.)**

Fig. 150 shows the small portable fittings to be used on the ship. A is a quadrant with degrees carefully marked on a piece of wood which is firmly secured on the ship's deck with its inner edge AB kept parallel to the middle line of the ship; C is a batten about 4 feet long and 3 inches broad, with two upright wire sights one in each end, about 8 feet long. The batten is placed on the quadrant, with the centre of one end coinciding with the centre of the quadrant, secured with a pin through the hole, so that it can revolve. A line AB, (fig. 151) is set off in a fore and aft direction, of any convenient length, and at its foremost end a straight batten D is placed vertically to the ship's side, being a few feet above the water.

The same arrangement is laid out on each side of the ship, and a line joining the centres of the batten D, D will be at right angles to the middle line of the ship. These are all the fittings necessary. When the helm is hard over, and the ship has fairly commenced her new course, throw overboard a small wooden box about a foot square and painted black: as the ship moves onwards the box remains nearly stationary on the water, till presently the ship has described a semicircle, which is marked by the two batten D, D and the box coming into the same straight line. At that instant the batten C is made to revolve, and the two wire sights S, S and the box are in the same straight line. The angle A (fig. 151) is then known, being denoted by the arc AC on the quadrant. The angle B is a right angle, and the distance AB being known, then  $BO = \text{tangent } A \times BA$ , to which must be added twice the breadth of the ship for the greatest space occupied by her in describing the circle.—*Ex.*: If the angle A be  $15'$ , and the base BA = 90 feet, and the breadth of the ship = 40 feet, then the greatest space occupied by her in describing the circle is  $= (90 \times 5.81965) + (2 \times 40) = 603.768$  feet.

FIG. 150.

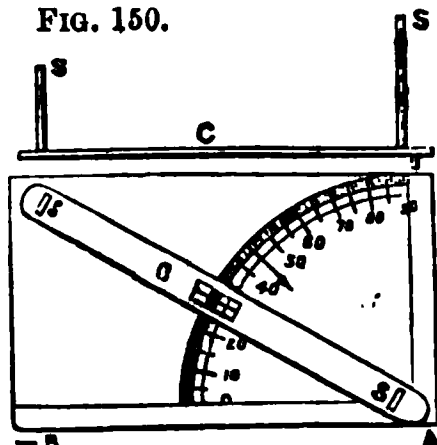
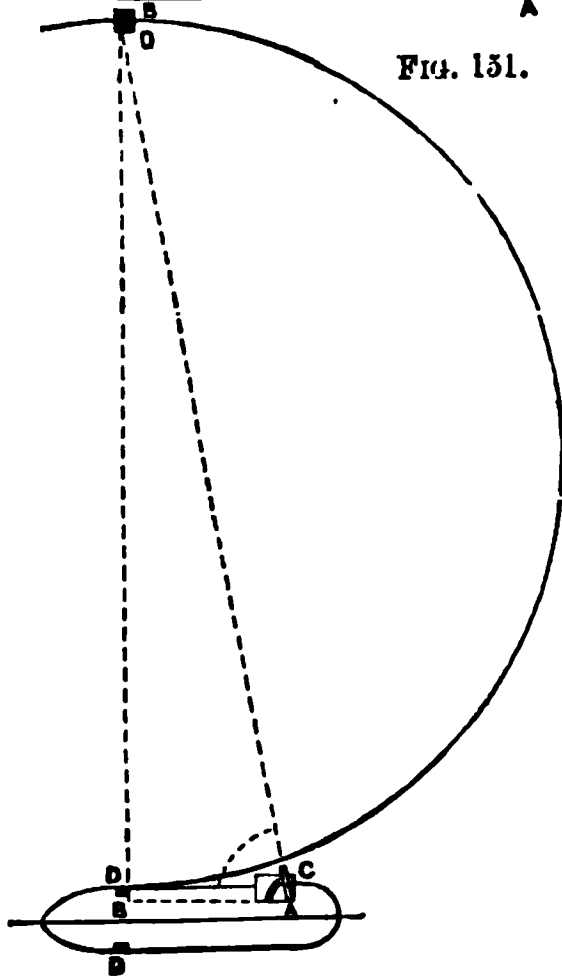


FIG. 151.



# 224 .      SQUARES, CUBES, ROOTS, AND RECIPROALS.

| No. | Square | Cube    | Square Root | Cube Root | Reciprocal |
|-----|--------|---------|-------------|-----------|------------|
| 95  | 9025   | 857375  | 9.7467948   | 4.5629026 | .010526816 |
| 96  | 9216   | 884786  | 9.7979590   | 4.5788570 | .010416667 |
| 97  | 9409   | 912678  | 9.8488578   | 4.5947009 | .010309278 |
| 98  | 9604   | 941192  | 9.8994949   | 4.6104363 | .010204082 |
| 99  | 9801   | 970299  | 9.9498744   | 4.6260650 | .010101010 |
| 100 | 10000  | 1000000 | 10.0000000  | 4.6415888 | .010000000 |
| 101 | 10201  | 1030301 | 10.0498756  | 4.6570095 | .009900990 |
| 102 | 10404  | 1061208 | 10.0995049  | 4.6723287 | .009803922 |
| 103 | 10609  | 1092727 | 10.1488916  | 4.6875482 | .009708788 |
| 104 | 10816  | 1124864 | 10.1980390  | 4.7026694 | .009615885 |
| 105 | 11025  | 1157625 | 10.2469508  | 4.7176940 | .009523810 |
| 106 | 11236  | 1191016 | 10.2956301  | 4.7326235 | .009433962 |
| 107 | 11449  | 1225048 | 10.3440804  | 4.7474594 | .009345794 |
| 108 | 11664  | 1259712 | 10.3923048  | 4.7622032 | .009259259 |
| 109 | 11881  | 1295029 | 10.4403065  | 4.7768562 | .009174312 |
| 110 | 12100  | 1331000 | 10.4880885  | 4.7914199 | .009090909 |
| 111 | 12321  | 1367681 | 10.5356538  | 4.8058955 | .009009009 |
| 112 | 12544  | 1404928 | 10.5830052  | 4.8202845 | .008928571 |
| 113 | 12769  | 1442897 | 10.6301458  | 4.8345881 | .008849558 |
| 114 | 12996  | 1481544 | 10.6770783  | 4.8488076 | .008771980 |
| 115 | 13225  | 1520875 | 10.7238053  | 4.8629442 | .008695652 |
| 116 | 13456  | 1560896 | 10.7703296  | 4.8769990 | .008620690 |
| 117 | 13689  | 1601613 | 10.8166538  | 4.8909732 | .008547009 |
| 118 | 13924  | 1643032 | 10.8627805  | 4.9048681 | .008474576 |
| 119 | 14161  | 1685159 | 10.9087121  | 4.9186847 | .008403361 |
| 120 | 14400  | 1728000 | 10.9544512  | 4.9324242 | .008333333 |
| 121 | 14641  | 1771561 | 11.0000000  | 4.9460874 | .008264463 |
| 122 | 14884  | 1815848 | 11.0453610  | 4.9596757 | .008196721 |
| 123 | 15129  | 1860867 | 11.0905365  | 4.9731898 | .008130081 |
| 124 | 15376  | 1906624 | 11.1355287  | 4.9866310 | .008064516 |
| 125 | 15625  | 1953125 | 11.1803399  | 5.0000000 | .008000000 |
| 126 | 15876  | 2000376 | 11.2249722  | 5.0132979 | .007936508 |
| 127 | 16129  | 2048383 | 11.2694277  | 5.0265257 | .007874016 |
| 128 | 16384  | 2097152 | 11.3137085  | 5.0396842 | .007812500 |
| 129 | 16641  | 2146689 | 11.3578167  | 5.0527748 | .007751938 |
| 130 | 16900  | 2197000 | 11.4017543  | 5.0657970 | .007692308 |
| 131 | 17161  | 2248091 | 11.4455281  | 5.0787531 | .007633588 |
| 132 | 17424  | 2299968 | 11.4891253  | 5.0916434 | .007575758 |
| 133 | 17689  | 2352637 | 11.5325626  | 5.1044687 | .007518797 |
| 134 | 17956  | 2406104 | 11.5758369  | 5.1172299 | .007462687 |
| 135 | 18225  | 2460375 | 11.6189500  | 5.1299278 | .007407407 |
| 136 | 18496  | 2515456 | 11.6619088  | 5.1425632 | .007352941 |
| 137 | 18769  | 2571353 | 11.7046999  | 5.1551367 | .007299270 |
| 138 | 19044  | 2628072 | 11.7473401  | 5.1676498 | .007246877 |
| 139 | 19321  | 2685619 | 11.7898261  | 5.1801015 | .007194245 |
| 140 | 19600  | 2744000 | 11.8321596  | 5.1924941 | .007142857 |
| 141 | 19881  | 2803221 | 11.8743422  | 5.2048279 | .007092199 |
| 142 | 20164  | 2863288 | 11.9163753  | 5.2171034 | .007042254 |
| 143 | 20449  | 2924207 | 11.9582607  | 5.2293215 | .006993007 |

| No. | Square | Cube    | Square Root | Cube Root | Reciprocal |
|-----|--------|---------|-------------|-----------|------------|
| 144 | 20736  | 2985984 | 12·0000000  | 5·2414828 | ·006944444 |
| 145 | 21025  | 3048625 | 12·0415946  | 5·2535879 | ·006896552 |
| 146 | 21316  | 3112186 | 12·0830460  | 5·2656374 | ·006849315 |
| 147 | 21609  | 3176523 | 12·1243557  | 5·2776321 | ·006802721 |
| 148 | 21904  | 3241792 | 12·1655251  | 5·2895725 | ·006756757 |
| 149 | 22201  | 3307949 | 12·2065556  | 5·3014592 | ·006711409 |
| 150 | 22500  | 3375000 | 12·2474487  | 5·3132928 | ·006666667 |
| 151 | 22801  | 3442951 | 12·2882057  | 5·3250740 | ·006622517 |
| 152 | 23104  | 3511808 | 12·3288280  | 5·3368033 | ·006578947 |
| 153 | 23409  | 3581577 | 12·3693169  | 5·3484812 | ·006535948 |
| 154 | 23716  | 3652264 | 12·4096736  | 5·3601084 | ·006493506 |
| 155 | 24025  | 3723875 | 12·4498996  | 5·3716854 | ·006451613 |
| 156 | 24336  | 3796416 | 12·4899960  | 5·3832126 | ·006410256 |
| 157 | 24649  | 3869893 | 12·5299641  | 5·3946907 | ·006369427 |
| 158 | 24964  | 3944312 | 12·5698051  | 5·4061202 | ·006329114 |
| 159 | 25281  | 4019679 | 12·6095202  | 5·4175015 | ·006289308 |
| 160 | 25600  | 4096000 | 12·6491106  | 5·4288352 | ·006250000 |
| 161 | 25921  | 4173281 | 12·6885775  | 5·4401218 | ·006211180 |
| 162 | 26244  | 4251528 | 12·7279221  | 5·4513618 | ·006172810 |
| 163 | 26569  | 4330747 | 12·7671453  | 5·4625556 | ·006134969 |
| 164 | 26896  | 4410944 | 12·8062485  | 5·4737037 | ·006097561 |
| 165 | 27225  | 4492125 | 12·8452326  | 5·4848066 | ·006060606 |
| 166 | 27556  | 4574296 | 12·8840987  | 5·4958647 | ·006024096 |
| 167 | 27889  | 4657463 | 12·9228480  | 5·5068784 | ·005988024 |
| 168 | 28224  | 4741632 | 12·9614814  | 5·5178484 | ·005952381 |
| 169 | 28561  | 4826809 | 13·0000000  | 5·5287748 | ·005917160 |
| 170 | 28900  | 4913000 | 13·0384048  | 5·5396583 | ·005882353 |
| 171 | 29241  | 5000211 | 13·0766968  | 5·5504991 | ·005847953 |
| 172 | 29584  | 5088448 | 13·1148770  | 5·5612978 | ·005813953 |
| 173 | 29929  | 5177717 | 13·1529464  | 5·5720546 | ·005780347 |
| 174 | 30276  | 5268024 | 13·1909060  | 5·5827702 | ·005747126 |
| 175 | 30625  | 5359375 | 13·2287566  | 5·5934447 | ·005714286 |
| 176 | 30976  | 5451776 | 13·2664992  | 5·6040787 | ·005681818 |
| 177 | 31329  | 5545233 | 13·3041347  | 5·6146724 | ·005649718 |
| 178 | 31684  | 5639752 | 13·3416641  | 5·6252268 | ·005617978 |
| 179 | 32041  | 5735339 | 13·3790882  | 5·6357408 | ·005586592 |
| 180 | 32400  | 5832000 | 13·4164079  | 5·6462162 | ·005555556 |
| 181 | 32761  | 5929741 | 13·4536240  | 5·6566528 | ·005524862 |
| 182 | 33124  | 6028568 | 13·4907376  | 5·6670511 | ·005494505 |
| 183 | 33489  | 6128487 | 13·5277493  | 5·6774114 | ·005464481 |
| 184 | 33856  | 6229504 | 13·5646600  | 5·6877340 | ·005434783 |
| 185 | 34225  | 6331625 | 13·6014705  | 5·6980192 | ·005405405 |
| 186 | 34596  | 6434856 | 13·6381817  | 5·7082675 | ·005376844 |
| 187 | 34969  | 6539208 | 13·6747948  | 5·7184791 | ·005347594 |
| 188 | 35344  | 6644672 | 13·7113092  | 5·7286548 | ·005319149 |
| 189 | 35721  | 6751269 | 13·7477271  | 5·7387936 | ·005291005 |
| 190 | 36100  | 6859000 | 13·7840488  | 5·7488971 | ·005263158 |
| 191 | 36481  | 6967871 | 13·8202750  | 5·7589652 | ·005235602 |
| 192 | 36864  | 7077888 | 13·8564065  | 5·7689982 | ·005208338 |

| No. | Square | Cube     | Square Root | Cube Root | Reciprocal |
|-----|--------|----------|-------------|-----------|------------|
| 193 | 37249  | 7189057  | 13.8924440  | 5.7789966 | .005181347 |
| 194 | 37636  | 7301384  | 13.9283883  | 5.7889604 | .005154689 |
| 195 | 38025  | 7414875  | 13.9642400  | 5.7988900 | .005128205 |
| 196 | 38416  | 7529536  | 14.0000000  | 5.8087857 | .005102041 |
| 197 | 38809  | 7645873  | 14.0356688  | 5.8186479 | .005076142 |
| 198 | 39204  | 7762392  | 14.0712473  | 5.8284767 | .005050505 |
| 199 | 39601  | 7880599  | 14.1067360  | 5.8382725 | .005025126 |
| 200 | 40000  | 8000000  | 14.1421856  | 5.8480355 | .005000000 |
| 201 | 40401  | 8120601  | 14.1774469  | 5.8577660 | .004975124 |
| 202 | 40804  | 8242408  | 14.2126704  | 5.8674643 | .004950495 |
| 203 | 41209  | 8365427  | 14.2478068  | 5.8771307 | .004926108 |
| 204 | 41616  | 8489664  | 14.2828569  | 5.8867653 | .004901961 |
| 205 | 42025  | 8615125  | 14.3178211  | 5.8963685 | .004878049 |
| 206 | 42436  | 8741816  | 14.3527001  | 5.9059406 | .004854369 |
| 207 | 42849  | 8869743  | 14.3874946  | 5.9154817 | .004830918 |
| 208 | 43264  | 8998912  | 14.4222051  | 5.9249921 | .004807692 |
| 209 | 43681  | 9129329  | 14.4568323  | 5.9344721 | .004784689 |
| 210 | 44100  | 9261000  | 14.4913767  | 5.9439220 | .004761905 |
| 211 | 44521  | 9393931  | 14.5258390  | 5.9533418 | .004739336 |
| 212 | 44944  | 9528128  | 14.5602198  | 5.9627320 | .004716981 |
| 213 | 45369  | 9663597  | 14.5945195  | 5.9720926 | .004694836 |
| 214 | 45796  | 9800344  | 14.6287888  | 5.9814240 | .004672897 |
| 215 | 46225  | 9938875  | 14.6628783  | 5.9907264 | .004651163 |
| 216 | 46656  | 10077696 | 14.6969385  | 6.0000000 | .004629630 |
| 217 | 47089  | 10218313 | 14.7309199  | 6.0092450 | .004608295 |
| 218 | 47524  | 10360232 | 14.7648231  | 6.0184617 | .004587156 |
| 219 | 47961  | 10503459 | 14.7986486  | 6.0276502 | .004566210 |
| 220 | 48400  | 10648000 | 14.8323970  | 6.0368107 | .004545455 |
| 221 | 48841  | 10793861 | 14.8660687  | 6.0459435 | .004524887 |
| 222 | 49284  | 10941048 | 14.8996644  | 6.0550489 | .004504505 |
| 223 | 49729  | 11089567 | 14.9331845  | 6.0641270 | .004484305 |
| 224 | 50176  | 11239424 | 14.9666295  | 6.0731779 | .004464286 |
| 225 | 50625  | 11390625 | 15.0000000  | 6.0822020 | .004444444 |
| 226 | 51076  | 11543176 | 15.0332964  | 6.0911994 | .004424779 |
| 227 | 51529  | 11697083 | 15.0665192  | 6.1001702 | .004405286 |
| 228 | 51984  | 11852352 | 15.0996689  | 6.1091147 | .004385965 |
| 229 | 52441  | 12008989 | 15.1327460  | 6.1180332 | .004366812 |
| 230 | 52900  | 12167000 | 15.1657509  | 6.1269257 | .004347826 |
| 231 | 53361  | 12326391 | 15.1986842  | 6.1357924 | .004329004 |
| 232 | 53824  | 12487168 | 15.2315462  | 6.1446337 | .004310345 |
| 233 | 54289  | 12649387 | 15.2643375  | 6.1534495 | .004291845 |
| 234 | 54756  | 12812904 | 15.2970585  | 6.1622401 | .004273504 |
| 235 | 55225  | 12977875 | 15.3297097  | 6.1710058 | .004255319 |
| 236 | 55696  | 13144256 | 15.3622915  | 6.1797466 | .004237288 |
| 237 | 56169  | 13312053 | 15.3948043  | 6.1884628 | .004219409 |
| 238 | 56644  | 13481272 | 15.4272486  | 6.1971544 | .004201681 |
| 239 | 57121  | 13651919 | 15.4596248  | 6.2058218 | .004184100 |
| 240 | 57600  | 13824000 | 15.4919334  | 6.2144650 | .004166667 |
| 241 | 58081  | 13997521 | 15.5241747  | 6.2230843 | .004149378 |

| No. | Square | Cube     | Square Root | Cube Root | Reciprocal |
|-----|--------|----------|-------------|-----------|------------|
| 242 | 58564  | 14712488 | 15.5563492  | 6.2316797 | .004132281 |
| 243 | 59049  | 14348907 | 15.5884573  | 6.2402515 | .004115226 |
| 244 | 59536  | 14526784 | 15.6204994  | 6.2487998 | .004098361 |
| 245 | 60025  | 14706125 | 15.6524758  | 6.2573248 | .004081633 |
| 246 | 60516  | 14886936 | 15.6843871  | 6.2658266 | .004065041 |
| 247 | 61009  | 15069223 | 15.7162336  | 6.2743054 | .004048583 |
| 248 | 61504  | 15252992 | 15.7480157  | 6.2827613 | .004032258 |
| 249 | 62001  | 15438249 | 15.7797338  | 6.2911946 | .004016064 |
| 250 | 62500  | 15625000 | 15.8118883  | 6.2996053 | .004000000 |
| 251 | 63001  | 15813251 | 15.8429795  | 6.3079935 | .003984064 |
| 252 | 63504  | 16003008 | 15.8745079  | 6.3163596 | .003968254 |
| 253 | 64009  | 16194277 | 15.9059737  | 6.3247035 | .003952569 |
| 254 | 64516  | 16387064 | 15.9373775  | 6.3330256 | .003937008 |
| 255 | 65025  | 16581375 | 15.9687194  | 6.3413257 | .003921569 |
| 256 | 65536  | 16777216 | 16.0000000  | 6.3496042 | .003906250 |
| 257 | 66049  | 16974593 | 16.0312195  | 6.3578611 | .003891051 |
| 258 | 66564  | 17173512 | 16.0623784  | 6.3660968 | .003875969 |
| 259 | 67081  | 17373979 | 16.0934769  | 6.3743111 | .003861004 |
| 260 | 67600  | 17576000 | 16.1245155  | 6.3825048 | .003846154 |
| 261 | 68121  | 17779581 | 16.1554944  | 6.3906765 | .003831418 |
| 262 | 68644  | 17984728 | 16.1864141  | 6.3988279 | .003816794 |
| 263 | 69169  | 18191447 | 16.2172747  | 6.4069585 | .003802281 |
| 264 | 69696  | 18399744 | 16.2480768  | 6.4150687 | .003787879 |
| 265 | 70225  | 18609625 | 16.2788206  | 6.4231583 | .003773585 |
| 266 | 70756  | 18821096 | 16.3095064  | 6.4312276 | .003759398 |
| 267 | 71289  | 19034163 | 16.3401346  | 6.4392767 | .003745318 |
| 268 | 71824  | 19248832 | 16.3707055  | 6.4473057 | .003731343 |
| 269 | 72361  | 19465109 | 16.4012195  | 6.4553148 | .003717472 |
| 270 | 72900  | 19683000 | 16.4316767  | 6.4633041 | .003703704 |
| 271 | 73441  | 19902511 | 16.4620776  | 6.4712736 | .003690037 |
| 272 | 73984  | 20123648 | 16.4924225  | 6.4792286 | .003676471 |
| 273 | 74529  | 20346417 | 16.5227116  | 6.4871541 | .003663004 |
| 274 | 75076  | 20570824 | 16.5529454  | 6.4950653 | .003649635 |
| 275 | 75625  | 20796875 | 16.5831240  | 6.5029572 | .003636364 |
| 276 | 76176  | 21024576 | 16.6132477  | 6.5108300 | .003623188 |
| 277 | 76729  | 21253983 | 16.6433170  | 6.5186839 | .003610108 |
| 278 | 77284  | 21484952 | 16.6733320  | 6.5265189 | .003597122 |
| 279 | 77841  | 21717639 | 16.7032931  | 6.5343335 | .003584229 |
| 280 | 78400  | 21952000 | 16.7332005  | 6.5421326 | .003571429 |
| 281 | 78961  | 22188041 | 16.7630546  | 6.5499116 | .003558719 |
| 282 | 79524  | 22425768 | 16.7928556  | 6.5576722 | .003546099 |
| 283 | 80089  | 22665187 | 16.8226088  | 6.5654144 | .003533569 |
| 284 | 80656  | 22906304 | 16.8522995  | 6.5731385 | .003521127 |
| 285 | 81225  | 23149125 | 16.8819430  | 6.5808448 | .003508772 |
| 286 | 81796  | 23393656 | 16.9115345  | 6.5885328 | .003496503 |
| 287 | 82369  | 23639903 | 16.9410743  | 6.5962023 | .003484321 |
| 288 | 82944  | 23887872 | 16.9705627  | 6.6038545 | .003472222 |
| 289 | 83521  | 24137569 | 17.0000000  | 6.6114890 | .003460208 |
| 290 | 84100  | 24389000 | 17.0293864  | 6.6191060 | .003448276 |

| No. | Square | Cube     | Square Root | Cube Root | Reciprocal |
|-----|--------|----------|-------------|-----------|------------|
| 291 | 84681  | 24642171 | 17.0587221  | 6.6267054 | .003436426 |
| 292 | 85264  | 24897088 | 17.0880075  | 6.6342874 | .003424658 |
| 293 | 85849  | 25153757 | 17.1172428  | 6.6418522 | .003412969 |
| 294 | 86436  | 25412184 | 17.1464282  | 6.6493998 | .003401361 |
| 295 | 87025  | 25672375 | 17.1755640  | 6.6569302 | .003389881 |
| 296 | 87616  | 25934336 | 17.2046505  | 6.6644437 | .003378878 |
| 297 | 88209  | 26198073 | 17.2336879  | 6.6719408 | .003367003 |
| 298 | 88804  | 26463592 | 17.2626765  | 6.6794200 | .003355705 |
| 299 | 89401  | 26730899 | 17.2916165  | 6.6868881 | .003344482 |
| 300 | 90000  | 27000000 | 17.3205081  | 6.6943295 | .003333333 |
| 301 | 90601  | 27270901 | 17.3493516  | 6.7017598 | .003322259 |
| 302 | 91204  | 27543608 | 17.3781472  | 6.7091729 | .003311258 |
| 303 | 91809  | 27818127 | 17.4068952  | 6.7165700 | .003300380 |
| 304 | 92416  | 28094464 | 17.4355958  | 6.7239508 | .003289474 |
| 305 | 93025  | 28372625 | 17.4642492  | 6.7313155 | .003278689 |
| 306 | 93636  | 28652616 | 17.4928557  | 6.7386641 | .003267974 |
| 307 | 94249  | 28934443 | 17.5214155  | 6.7459967 | .003257329 |
| 308 | 94864  | 29218112 | 17.5499288  | 6.7533134 | .003246753 |
| 309 | 95481  | 29503629 | 17.5783958  | 6.7606148 | .003236246 |
| 310 | 96100  | 29791000 | 17.6068169  | 6.7678995 | .003225806 |
| 311 | 96721  | 30080231 | 17.6351921  | 6.7751690 | .003215434 |
| 312 | 97344  | 30371328 | 17.6635217  | 6.7824229 | .003205128 |
| 313 | 97969  | 30664297 | 17.6918060  | 6.7896613 | .003194888 |
| 314 | 98596  | 30959144 | 17.7200451  | 6.7968844 | .003184713 |
| 315 | 99225  | 31255875 | 17.7482393  | 6.8040921 | .003174603 |
| 316 | 99856  | 31554496 | 17.7763888  | 6.8112847 | .003164557 |
| 317 | 100489 | 31855013 | 17.8044938  | 6.8184620 | .003154574 |
| 318 | 101124 | 32157432 | 17.8325545  | 6.8256242 | .003144654 |
| 319 | 101761 | 32461759 | 17.8605711  | 6.8327714 | .003134796 |
| 320 | 102400 | 32768000 | 17.8885438  | 6.8399037 | .003125000 |
| 321 | 103041 | 32076161 | 17.9164729  | 6.8470213 | .003115265 |
| 322 | 103684 | 33386248 | 17.9443584  | 6.8541240 | .003105590 |
| 323 | 104329 | 33698267 | 17.9722008  | 6.8612120 | .003095975 |
| 324 | 104976 | 34012224 | 18.0000000  | 6.8682855 | .003086420 |
| 325 | 105625 | 34328125 | 18.0277564  | 6.8753443 | .003076923 |
| 326 | 106276 | 34645976 | 18.0554701  | 6.8823888 | .003067485 |
| 327 | 106929 | 34965783 | 18.0831413  | 6.8894188 | .003058104 |
| 328 | 107584 | 35287552 | 18.1107703  | 6.8964345 | .003048780 |
| 329 | 108241 | 35611289 | 18.1383571  | 6.9034359 | .003039514 |
| 330 | 108900 | 35937000 | 18.1659021  | 6.9104232 | .003030303 |
| 331 | 109561 | 36264691 | 18.1934054  | 6.9173964 | .003021148 |
| 332 | 110224 | 36594368 | 18.2208672  | 6.9243556 | .003012048 |
| 333 | 110889 | 36926037 | 18.2482876  | 6.9313008 | .003003003 |
| 334 | 111556 | 37259704 | 18.2756669  | 6.9382321 | .002994012 |
| 335 | 112225 | 37595375 | 18.3030052  | 6.9451496 | .002985075 |
| 336 | 112896 | 37933056 | 18.3303028  | 6.9520538 | .002976190 |
| 337 | 113569 | 38272753 | 18.3575598  | 6.9589434 | .002967359 |
| 338 | 114244 | 38614472 | 18.3847763  | 6.9658198 | .002958580 |
| 339 | 114921 | 38958219 | 18.4119526  | 6.9726826 | .002949853 |

| No. | Square | Cube     | Square Root | Cube Root | Reciprocal |
|-----|--------|----------|-------------|-----------|------------|
| 840 | 115600 | 89304000 | 18.4890889  | 6.9795321 | .002941176 |
| 841 | 116281 | 89651821 | 18.4661853  | 6.9863681 | .002932551 |
| 842 | 116964 | 40001688 | 18.4932420  | 6.9931906 | .002923977 |
| 843 | 117649 | 40358607 | 18.5202592  | 7.0000000 | .002915452 |
| 844 | 118336 | 40707584 | 18.5472370  | 7.0067962 | .002906977 |
| 845 | 119025 | 41063625 | 18.5741756  | 7.0135791 | .002898551 |
| 846 | 119716 | 41421736 | 18.6010752  | 7.0203490 | .002890173 |
| 847 | 120409 | 41781928 | 18.6279360  | 7.0271058 | .002881844 |
| 848 | 121104 | 42144192 | 18.6547581  | 7.0338497 | .002873563 |
| 849 | 121801 | 42508549 | 18.6815147  | 7.0405806 | .002865330 |
| 850 | 122500 | 42875000 | 18.7082869  | 7.0472987 | .002857143 |
| 851 | 123201 | 43243551 | 18.7349940  | 7.0540041 | .002849003 |
| 852 | 123904 | 43614208 | 18.7616680  | 7.0606967 | .002840909 |
| 853 | 124609 | 43986977 | 18.7882942  | 7.0673767 | .002832861 |
| 854 | 125316 | 44361864 | 18.8148877  | 7.0740440 | .002824859 |
| 855 | 126025 | 44738875 | 18.8414437  | 7.0806988 | .002816901 |
| 856 | 126736 | 45118016 | 18.8679623  | 7.0873411 | .002808989 |
| 857 | 127449 | 45499293 | 18.8944486  | 7.0939709 | .002801120 |
| 858 | 128164 | 45882712 | 18.9208879  | 7.1005885 | .002793296 |
| 859 | 128881 | 46268279 | 18.9472958  | 7.1071937 | .002785515 |
| 860 | 129600 | 46656000 | 18.9736660  | 7.1137866 | .002777778 |
| 861 | 130321 | 47045881 | 19.0000000  | 7.1203674 | .002770083 |
| 862 | 131044 | 47437928 | 19.0262976  | 7.1269360 | .002762481 |
| 863 | 131769 | 47832147 | 19.0525589  | 7.1334925 | .002754821 |
| 864 | 132496 | 48228544 | 19.0787840  | 7.1400370 | .002747253 |
| 865 | 133225 | 48627125 | 19.1049732  | 7.1465695 | .002739726 |
| 866 | 133956 | 49027896 | 19.1311265  | 7.1530901 | .002732240 |
| 867 | 134689 | 49430863 | 19.1572441  | 7.1595988 | .002724796 |
| 868 | 135424 | 49836082 | 19.1833261  | 7.1660957 | .002717391 |
| 869 | 136161 | 50243409 | 19.2093727  | 7.1725809 | .002710027 |
| 870 | 136900 | 50653000 | 19.2353841  | 7.1790544 | .002702703 |
| 871 | 137641 | 51064811 | 19.2613608  | 7.1855162 | .002695418 |
| 872 | 138384 | 51478848 | 19.2873015  | 7.1919668 | .002688172 |
| 873 | 139129 | 51895117 | 19.3132079  | 7.1984050 | .002680965 |
| 874 | 139876 | 52313624 | 19.3390796  | 7.2048322 | .002673797 |
| 875 | 140625 | 52734375 | 19.3649167  | 7.2112479 | .002666667 |
| 876 | 141376 | 53157876 | 19.3907194  | 7.2176522 | .002659574 |
| 877 | 142129 | 53582633 | 19.4164878  | 7.2240450 | .002652520 |
| 878 | 142884 | 54010152 | 19.4422221  | 7.2304268 | .002645503 |
| 879 | 143641 | 54439989 | 19.4679223  | 7.2367972 | .002638522 |
| 880 | 144400 | 54872000 | 19.4935887  | 7.2431565 | .002631579 |
| 881 | 145161 | 55306841 | 19.5192218  | 7.2495045 | .002624672 |
| 882 | 145924 | 55742968 | 19.5448203  | 7.2558415 | .002617801 |
| 883 | 146689 | 56181887 | 19.5703858  | 7.2621675 | .002610966 |
| 884 | 147456 | 56623104 | 19.5959179  | 7.2684824 | .002604167 |
| 885 | 148225 | 57066625 | 19.6214169  | 7.2747864 | .002597403 |
| 886 | 148996 | 57512456 | 19.6468827  | 7.2810794 | .002590674 |
| 887 | 149769 | 57960603 | 19.6723156  | 7.2873617 | .002583979 |
| 888 | 150544 | 58411072 | 19.6977156  | 7.2936380 | .002577320 |



| No. | Square | Cube     | Square Root | Cube Root | Reciprocal |
|-----|--------|----------|-------------|-----------|------------|
| 389 | 151321 | 58868869 | 19.7230829  | 7.2998936 | .002570694 |
| 390 | 152100 | 59819000 | 19.7484177  | 7.8061436 | .002564108 |
| 391 | 152881 | 59776471 | 19.7737199  | 7.8123828 | .002557545 |
| 392 | 153664 | 60286288 | 19.7989899  | 7.8186114 | .002551020 |
| 393 | 154449 | 60698457 | 19.8242276  | 7.8248295 | .002544529 |
| 394 | 155236 | 61162984 | 19.8494882  | 7.8310369 | .002538071 |
| 395 | 156025 | 61629875 | 19.8746069  | 7.8372339 | .002531646 |
| 396 | 156816 | 62099186 | 19.8997487  | 7.8434205 | .002525258 |
| 397 | 157609 | 62570773 | 19.9248588  | 7.8495966 | .002518892 |
| 398 | 158404 | 63044792 | 19.9499873  | 7.8557624 | .002512568 |
| 399 | 159201 | 63521199 | 19.9749844  | 7.8619178 | .002506266 |
| 400 | 160000 | 64000000 | 20.0000000  | 7.8680680 | .002500000 |
| 401 | 160801 | 64481201 | 20.0249844  | 7.8741979 | .002493766 |
| 402 | 161604 | 64964808 | 20.0499877  | 7.8803227 | .002487562 |
| 403 | 162409 | 65450827 | 20.0748599  | 7.8864373 | .002481890 |
| 404 | 163216 | 65939264 | 20.0997512  | 7.8925418 | .002475248 |
| 405 | 164025 | 66430125 | 20.1246118  | 7.8986368 | .002469186 |
| 406 | 164836 | 66923416 | 20.1494417  | 7.4047206 | .002463054 |
| 407 | 165649 | 67419148 | 20.1742410  | 7.4107950 | .002457002 |
| 408 | 166464 | 67917312 | 20.1990099  | 7.4168595 | .002450980 |
| 409 | 167281 | 68417929 | 20.2237484  | 7.4229142 | .002444988 |
| 410 | 168100 | 68921000 | 20.2484567  | 7.4289589 | .002439024 |
| 411 | 168921 | 69426531 | 20.2731849  | 7.4349938 | .002433090 |
| 412 | 169744 | 69934528 | 20.2977881  | 7.4410189 | .002427184 |
| 413 | 170569 | 70444997 | 20.3224014  | 7.4470842 | .002421308 |
| 414 | 171396 | 70957944 | 20.3469899  | 7.4530899 | .002415459 |
| 415 | 172225 | 71473375 | 20.3715488  | 7.4590359 | .002409689 |
| 416 | 173056 | 71991296 | 20.3960781  | 7.4650223 | .002403846 |
| 417 | 173889 | 72511713 | 20.4205779  | 7.4709991 | .002398082 |
| 418 | 174724 | 73034632 | 20.4450483  | 7.4769664 | .002392844 |
| 419 | 175561 | 73560059 | 20.4694895  | 7.4829242 | .002386685 |
| 420 | 176400 | 74088000 | 20.4939015  | 7.4888724 | .002380952 |
| 421 | 177241 | 74618461 | 20.5182845  | 7.4948113 | .002375297 |
| 422 | 178084 | 75151448 | 20.5426886  | 7.5007406 | .002369668 |
| 423 | 178929 | 75686967 | 20.5669688  | 7.5066607 | .002364066 |
| 424 | 179776 | 76225024 | 20.5912608  | 7.5125715 | .002358491 |
| 425 | 180625 | 76765625 | 20.6155281  | 7.5184730 | .002352941 |
| 426 | 181476 | 77308776 | 20.6397674  | 7.5243652 | .002347418 |
| 427 | 182329 | 77854483 | 20.6639788  | 7.5302482 | .002341920 |
| 428 | 183184 | 78402752 | 20.6881609  | 7.5361221 | .002336449 |
| 429 | 184041 | 78953589 | 20.7123152  | 7.5419867 | .002331002 |
| 430 | 184900 | 79507000 | 20.7364414  | 7.5478423 | .002325581 |
| 431 | 185761 | 80062991 | 20.7605895  | 7.5536888 | .002320186 |
| 432 | 186624 | 80621568 | 20.7846097  | 7.5595268 | .002314815 |
| 433 | 187489 | 81182787 | 20.8086520  | 7.5653548 | .002309469 |
| 434 | 188356 | 81746504 | 20.8326667  | 7.5711743 | .002304147 |
| 435 | 189225 | 82312875 | 20.8566536  | 7.5769849 | .002298851 |
| 436 | 190096 | 82881856 | 20.8806130  | 7.5827865 | .002293578 |
| 437 | 190969 | 83453453 | 20.9045450  | 7.5885793 | .002288380 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 438 | 191844 | 84027672  | 20·9284495  | 7·5943638 | ·002283105 |
| 439 | 192721 | 84604519  | 20·9523268  | 7·6001385 | ·002277004 |
| 440 | 193600 | 85184000  | 20·9761770  | 7·6059049 | ·002272727 |
| 441 | 194481 | 85766121  | 21·0000000  | 7·6116626 | ·002267574 |
| 442 | 195364 | 86350888  | 21·0237960  | 7·6174116 | ·002262443 |
| 443 | 196249 | 86938307  | 21·0475652  | 7·6231519 | ·002257386 |
| 444 | 197136 | 87528384  | 21·0713075  | 7·6288837 | ·002252252 |
| 445 | 198025 | 88121125  | 21·0950231  | 7·6346067 | ·002247191 |
| 446 | 198916 | 88716536  | 21·1187121  | 7·6403213 | ·002242152 |
| 447 | 199809 | 89314623  | 21·1423745  | 7·6460272 | ·002237186 |
| 448 | 200704 | 89915392  | 21·1660105  | 7·6517247 | ·002232143 |
| 449 | 201601 | 90518849  | 21·1896201  | 7·6574138 | ·002227171 |
| 450 | 202500 | 91125000  | 21·2132034  | 7·6630943 | ·002222222 |
| 451 | 203401 | 91733851  | 21·2367606  | 7·6687665 | ·002217295 |
| 452 | 204304 | 92345408  | 21·2602916  | 7·6744303 | ·002212389 |
| 453 | 205209 | 92959677  | 21·2837967  | 7·6800857 | ·002207506 |
| 454 | 206116 | 93576664  | 21·3072758  | 7·6857328 | ·002202643 |
| 455 | 207025 | 94196375  | 21·3307290  | 7·6913717 | ·002197802 |
| 456 | 207936 | 94818816  | 21·3541565  | 7·6970023 | ·002192982 |
| 457 | 208849 | 95443993  | 21·3775583  | 7·7026246 | ·002188184 |
| 458 | 209764 | 96071912  | 21·4009346  | 7·7082388 | ·002183406 |
| 459 | 210681 | 96702579  | 21·4242853  | 7·7138448 | ·002178649 |
| 460 | 211600 | 97336000  | 21·4476106  | 7·7194426 | ·002173913 |
| 461 | 212521 | 97972181  | 21·4709106  | 7·7250325 | ·002169197 |
| 462 | 213444 | 98611128  | 21·4941853  | 7·7306141 | ·002164502 |
| 463 | 214369 | 99252847  | 21·5174348  | 7·7361877 | ·002159827 |
| 464 | 215296 | 99897344  | 21·5406592  | 7·7417532 | ·002155172 |
| 465 | 216225 | 100544625 | 21·5638587  | 7·7473109 | ·002150588 |
| 466 | 217156 | 101194696 | 21·5870331  | 7·7528606 | ·002145923 |
| 467 | 218089 | 101847563 | 21·6101828  | 7·7584023 | ·002141328 |
| 468 | 219024 | 102503232 | 21·6333077  | 7·7639361 | ·002136752 |
| 469 | 219961 | 103161709 | 21·6564078  | 7·7694620 | ·002132196 |
| 470 | 220900 | 103823000 | 21·6794834  | 7·7749801 | ·002127660 |
| 471 | 221841 | 104487111 | 21·7025344  | 7·7804904 | ·002123142 |
| 472 | 222784 | 105154048 | 21·7255610  | 7·7859928 | ·002118644 |
| 473 | 223729 | 105823817 | 21·7485632  | 7·7914875 | ·002114165 |
| 474 | 224676 | 106496424 | 21·7715411  | 7·7969745 | ·002109705 |
| 475 | 225625 | 107171875 | 21·7944947  | 7·8024538 | ·002105263 |
| 476 | 226576 | 107850176 | 21·8174242  | 7·8079254 | ·002100840 |
| 477 | 227529 | 108531333 | 21·8403297  | 7·8133892 | ·002096436 |
| 478 | 228484 | 109215352 | 21·8632111  | 7·8188456 | ·002092050 |
| 479 | 229441 | 109902239 | 21·8860686  | 7·8242942 | ·002087683 |
| 480 | 230400 | 110592000 | 21·9089023  | 7·8297353 | ·002083333 |
| 481 | 231361 | 111284641 | 21·9317122  | 7·8351688 | ·002079002 |
| 482 | 232324 | 111980168 | 21·9544984  | 7·8405949 | ·002074689 |
| 483 | 233289 | 112678587 | 21·9772610  | 7·8460134 | ·002070393 |
| 484 | 234256 | 113379904 | 22·0000000  | 7·8514244 | ·002066116 |
| 485 | 235225 | 114084125 | 22·0227155  | 7·8568281 | ·002061856 |
| 486 | 236196 | 114791256 | 22·0454077  | 7·8622242 | ·002057613 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 487 | 237169 | 115501303 | 22-0680765  | 7-8676130 | ·002053388 |
| 488 | 238144 | 116214272 | 22-0907220  | 7-8729944 | ·002049180 |
| 489 | 239121 | 116930169 | 22-1133444  | 7-8783684 | ·002044990 |
| 490 | 240100 | 117649000 | 22-1359436  | 7-8837352 | ·002040816 |
| 491 | 241081 | 118370771 | 22-1585198  | 7-8890946 | ·002036660 |
| 492 | 242064 | 119095488 | 22-1810730  | 7-8944468 | ·002032520 |
| 493 | 243049 | 119823157 | 22-2036033  | 7-8997917 | ·002028398 |
| 494 | 244036 | 120553784 | 22-2261108  | 7-9051294 | ·002024291 |
| 495 | 245025 | 121287375 | 22-2485955  | 7-9104599 | ·002020202 |
| 496 | 246016 | 122023936 | 22-2710575  | 7-9157832 | ·002016129 |
| 497 | 247009 | 122763473 | 22-2934968  | 7-9210994 | ·002012072 |
| 498 | 248004 | 123505992 | 22-3159136  | 7-9264085 | ·002008082 |
| 499 | 249001 | 124251499 | 22-3383079  | 7-9317104 | ·002004008 |
| 500 | 250000 | 125000000 | 22-3606798  | 7-9370053 | ·002000000 |
| 501 | 251001 | 125751501 | 22-3830293  | 7-9422931 | ·001996008 |
| 502 | 252004 | 126506008 | 22-4053565  | 7-9475739 | ·001992032 |
| 503 | 253009 | 127263527 | 22-4276615  | 7-9528477 | ·001988072 |
| 504 | 254016 | 128024064 | 22-4499443  | 7-9581144 | ·001984127 |
| 505 | 255025 | 128787625 | 22-4722051  | 7-9633743 | ·001980198 |
| 506 | 256036 | 129554216 | 22-4944438  | 7-9686271 | ·001976285 |
| 507 | 257049 | 130328843 | 22-5166605  | 7-9738731 | ·001972387 |
| 508 | 258064 | 131096512 | 22-5388553  | 7-9791122 | ·001968504 |
| 509 | 259081 | 131872229 | 22-5610283  | 7-9843444 | ·001964637 |
| 510 | 260100 | 132651000 | 22-5831796  | 7-9895697 | ·001960784 |
| 511 | 261121 | 133432831 | 22-6053091  | 7-9947883 | ·001956947 |
| 512 | 262144 | 134217728 | 22-6274170  | 8-0000000 | ·001953125 |
| 513 | 263169 | 135005697 | 22-6495033  | 8-0052049 | ·001949318 |
| 514 | 264196 | 135796744 | 22-6715681  | 8-0104032 | ·001945525 |
| 515 | 265225 | 136590875 | 22-6936114  | 8-0155946 | ·001941748 |
| 516 | 266256 | 137388096 | 22-7156334  | 8-0207794 | ·001937984 |
| 517 | 267289 | 138188413 | 22-7376840  | 8-0259574 | ·001934236 |
| 518 | 268324 | 138991832 | 22-7596134  | 8-0311287 | ·001930502 |
| 519 | 269361 | 139798359 | 22-7815715  | 8-0362935 | ·001926782 |
| 520 | 270400 | 140608000 | 22-8035085  | 8-0414515 | ·001923077 |
| 521 | 271441 | 141420761 | 22-8254244  | 8-0466030 | ·001919386 |
| 522 | 272484 | 142236648 | 22-8473193  | 8-0517479 | ·001915709 |
| 523 | 273529 | 143055667 | 22-8691933  | 8-0568862 | ·001912046 |
| 524 | 274576 | 143877824 | 22-8910463  | 8-0620180 | ·001908397 |
| 525 | 275625 | 144703125 | 22-9128785  | 8-0671432 | ·001904762 |
| 526 | 276676 | 145531576 | 22-9346899  | 8-0722620 | ·001901141 |
| 527 | 277729 | 146363183 | 22-9564806  | 8-0773743 | ·001897533 |
| 528 | 278784 | 147197952 | 22-9782506  | 8-0824800 | ·001893939 |
| 529 | 279841 | 148035889 | 23-0000000  | 8-0875794 | ·001890359 |
| 530 | 280900 | 148877000 | 23-0217289  | 8-0926723 | ·001886792 |
| 531 | 281961 | 149721291 | 23-0434372  | 8-0977589 | ·001883239 |
| 532 | 283024 | 150568768 | 23-0651252  | 8-1028390 | ·001879699 |
| 533 | 284089 | 151419437 | 23-0867928  | 8-1079128 | ·001876173 |
| 534 | 285156 | 152273304 | 23-1084400  | 8-1129803 | ·001872659 |
| 535 | 286225 | 153130375 | 23-1300670  | 8-1180414 | ·001869159 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 536 | 287296 | 153990656 | 23·1516738  | 8·1230962 | ·001865672 |
| 537 | 288369 | 154854153 | 23·1732605  | 8·1281447 | ·001862197 |
| 538 | 289444 | 155720872 | 23·1948270  | 8·1331870 | ·001858736 |
| 539 | 290521 | 156590819 | 23·2163735  | 8·1382230 | ·001855288 |
| 540 | 291600 | 157464000 | 23·2379001  | 8·1432529 | ·001851852 |
| 541 | 292681 | 158340421 | 23·2594067  | 8·1482765 | ·001848429 |
| 542 | 293764 | 159220088 | 23·2808935  | 8·1532939 | ·001845018 |
| 543 | 294849 | 160103007 | 23·3023604  | 8·1583051 | ·001841621 |
| 544 | 295936 | 160989184 | 23·3238076  | 8·1633102 | ·001838235 |
| 545 | 297025 | 161878625 | 23·3452351  | 8·1683092 | ·001834862 |
| 546 | 298116 | 162771336 | 23·3666429  | 8·1733020 | ·001831502 |
| 547 | 299209 | 163667323 | 23·3880311  | 8·1782888 | ·001828154 |
| 548 | 300304 | 164566592 | 23·4093998  | 8·1832695 | ·001824818 |
| 549 | 301401 | 165469149 | 23·4307490  | 8·1882441 | ·001821494 |
| 550 | 302500 | 166375000 | 23·4520788  | 8·1932127 | ·001818182 |
| 551 | 303601 | 167284151 | 23·4733892  | 8·1981753 | ·001814882 |
| 552 | 304704 | 168196608 | 23·4946802  | 8·2031319 | ·001811594 |
| 553 | 305809 | 169112377 | 23·5159520  | 8·2080825 | ·001808318 |
| 554 | 306916 | 170031464 | 23·5372046  | 8·2130271 | ·001805054 |
| 555 | 308025 | 170953875 | 23·5584380  | 8·2179657 | ·001801802 |
| 556 | 309136 | 171879616 | 23·5796522  | 8·2228985 | ·001798561 |
| 557 | 310249 | 172808693 | 23·6008474  | 8·2278254 | ·001795332 |
| 558 | 311364 | 173741112 | 23·6220286  | 8·2327463 | ·001792115 |
| 559 | 312481 | 174676879 | 23·6431808  | 8·2376614 | ·001788909 |
| 560 | 313600 | 175616000 | 23·6643191  | 8·2425706 | ·001785714 |
| 561 | 314721 | 176558481 | 23·6854386  | 8·2474740 | ·001782531 |
| 562 | 315844 | 177504328 | 23·7065392  | 8·2523715 | ·001779359 |
| 563 | 316969 | 178453547 | 23·7276210  | 8·2572633 | ·001776199 |
| 564 | 318096 | 179406144 | 23·7486842  | 8·2621492 | ·001773050 |
| 565 | 319225 | 180362125 | 23·7697286  | 8·2670294 | ·001769912 |
| 566 | 320356 | 181321496 | 23·7907545  | 8·2719039 | ·001766784 |
| 567 | 321489 | 182284263 | 23·8117618  | 8·2767726 | ·001763668 |
| 568 | 322624 | 183250432 | 23·8327506  | 8·2816355 | ·001760563 |
| 569 | 323761 | 184220009 | 23·8537209  | 8·2864928 | ·001757469 |
| 570 | 324900 | 185193000 | 23·8746728  | 8·2913444 | ·001754386 |
| 571 | 326041 | 186169411 | 23·8956063  | 8·2961903 | ·001751313 |
| 572 | 327184 | 187149248 | 23·9165215  | 8·3010304 | ·001748252 |
| 573 | 328329 | 188132517 | 23·9374184  | 8·3058651 | ·001745201 |
| 574 | 329476 | 189119224 | 23·9582971  | 8·3106941 | ·001742160 |
| 575 | 330625 | 190109375 | 23·9791576  | 8·3155175 | ·001739130 |
| 576 | 331776 | 191102976 | 24·0000000  | 8·3203353 | ·001736111 |
| 577 | 332929 | 192100033 | 24·0208243  | 8·3251475 | ·001733102 |
| 578 | 334084 | 193100552 | 24·0416306  | 8·3299542 | ·001730104 |
| 579 | 335241 | 194104539 | 24·0624188  | 8·3347553 | ·001727116 |
| 580 | 336400 | 195112000 | 24·0831891  | 8·3395509 | ·001724138 |
| 581 | 337561 | 196122941 | 24·1039416  | 8·3443410 | ·001721170 |
| 582 | 338724 | 197137368 | 24·1246762  | 8·3491256 | ·001718213 |
| 583 | 339889 | 198155287 | 24·1453929  | 8·3539047 | ·001715266 |
| 584 | 341056 | 199176704 | 24·1660919  | 8·3586784 | ·001712329 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 585 | 342225 | 200201625 | 24·1867732  | 8·3634466 | ·001709402 |
| 586 | 343396 | 201230056 | 24·2074369  | 8·3682095 | ·001706485 |
| 587 | 344569 | 202262003 | 24·2280829  | 8·3729668 | ·001703578 |
| 588 | 345744 | 203297472 | 24·2487113  | 8·3777188 | ·005700680 |
| 589 | 346921 | 204386469 | 24·2693222  | 8·3824653 | ·001697793 |
| 590 | 348100 | 205379000 | 24·2899156  | 8·3872065 | ·001694915 |
| 591 | 349281 | 206425071 | 24·3104916  | 8·3919423 | ·001692047 |
| 592 | 350464 | 207474688 | 24·3310501  | 8·3966729 | ·001689189 |
| 593 | 351649 | 208527857 | 24·3515913  | 8·4013981 | ·001686341 |
| 594 | 352836 | 209584584 | 24·3721152  | 8·4061180 | ·001683502 |
| 595 | 354025 | 210644875 | 24·3926218  | 8·4108326 | ·001680672 |
| 596 | 355216 | 211708736 | 24·4131112  | 8·4155419 | ·001677852 |
| 597 | 356409 | 212776173 | 24·4335834  | 8·4202460 | ·001675042 |
| 598 | 357604 | 213847192 | 24·4540385  | 8·4249448 | ·001672241 |
| 599 | 358801 | 214921799 | 24·4744765  | 8·4296383 | ·001669449 |
| 600 | 360000 | 216000000 | 24·4948974  | 8·4343267 | ·001666667 |
| 601 | 361201 | 217081801 | 24·5153013  | 8·4390098 | ·001663894 |
| 602 | 362404 | 218167208 | 24·5356883  | 8·4436877 | ·001661180 |
| 603 | 363609 | 219256227 | 24·5560583  | 8·4483605 | ·001658375 |
| 604 | 364816 | 220348864 | 24·5764115  | 8·4530281 | ·001655629 |
| 605 | 366025 | 221445125 | 24·5967478  | 8·4576906 | ·001652898 |
| 606 | 367236 | 222545016 | 24·6170673  | 8·4623479 | ·001650165 |
| 607 | 368449 | 223648543 | 24·6373700  | 8·4670000 | ·001647446 |
| 608 | 369664 | 224755712 | 24·6576560  | 8·4716471 | ·001644737 |
| 609 | 370881 | 225866529 | 24·6779254  | 8·4762892 | ·001642036 |
| 610 | 372100 | 226981000 | 24·6981781  | 8·4809261 | ·001639344 |
| 611 | 373321 | 228099131 | 24·7184142  | 8·4855579 | ·001636661 |
| 612 | 374544 | 229220928 | 24·7386338  | 8·4901848 | ·001633987 |
| 613 | 375769 | 230346397 | 24·7588368  | 8·4948065 | ·001631321 |
| 614 | 376996 | 231475544 | 24·7790234  | 8·4994233 | ·001628664 |
| 615 | 378225 | 232608375 | 24·7991935  | 8·5040350 | ·001626016 |
| 616 | 379456 | 233744896 | 24·8193473  | 8·5086417 | ·001623377 |
| 617 | 380689 | 234885113 | 24·8394847  | 8·5132435 | ·001620746 |
| 618 | 381924 | 236029032 | 24·8596058  | 8·5178403 | ·001618123 |
| 619 | 383161 | 237176659 | 24·8797106  | 8·5224321 | ·001615509 |
| 620 | 384400 | 238328000 | 24·8997992  | 8·5270189 | ·001612903 |
| 621 | 385641 | 239483061 | 24·9198716  | 8·5316009 | ·001610306 |
| 622 | 386884 | 240641848 | 24·9399278  | 8·5361780 | ·001607717 |
| 623 | 388129 | 241804367 | 24·9599679  | 8·5407501 | ·001605136 |
| 624 | 389376 | 242970624 | 24·9799920  | 8·5453173 | ·001602564 |
| 625 | 390625 | 244140625 | 25·0000000  | 8·5498797 | ·001600000 |
| 626 | 391876 | 245314376 | 25·0199920  | 8·5544372 | ·001597444 |
| 627 | 393129 | 246491883 | 25·0399681  | 8·5589899 | ·001594896 |
| 628 | 394384 | 247673152 | 25·0599282  | 8·5635377 | ·001592357 |
| 629 | 395641 | 248858189 | 25·0798724  | 8·5680807 | ·001589825 |
| 630 | 396900 | 250047000 | 25·0998008  | 8·5726189 | ·001587302 |
| 631 | 398161 | 251239591 | 25·1197134  | 8·5771523 | ·001584786 |
| 632 | 399424 | 252435968 | 25·1396102  | 8·5816809 | ·001582278 |
| 633 | 400689 | 253636187 | 25·1594913  | 8·5862047 | ·001579779 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 634 | 401956 | 254840104 | 25.1793566  | 8.5907238 | .001577287 |
| 635 | 403225 | 256047875 | 25.1992063  | 8.5952380 | .001574803 |
| 636 | 404496 | 257259456 | 25.2190404  | 8.5997476 | .001572327 |
| 637 | 405769 | 258474853 | 25.2388589  | 8.6042525 | .001569859 |
| 638 | 407044 | 259694072 | 25.2586619  | 8.6087526 | .001567398 |
| 639 | 408321 | 260917119 | 25.2784493  | 8.6132480 | .001564945 |
| 640 | 409600 | 262144000 | 25.2982213  | 8.6177388 | .001562500 |
| 641 | 410881 | 263374721 | 25.3179778  | 8.6222248 | .001560062 |
| 642 | 412164 | 264609288 | 25.3377189  | 8.6267063 | .001557632 |
| 643 | 413449 | 265847707 | 25.3574447  | 8.6311830 | .001555210 |
| 644 | 414736 | 267089984 | 25.3771551  | 8.6356551 | .001552795 |
| 645 | 416025 | 268336125 | 25.3968502  | 8.6401226 | .001550388 |
| 646 | 417316 | 269586136 | 25.4165301  | 8.6445855 | .001547988 |
| 647 | 418609 | 270840023 | 25.4361947  | 8.6490437 | .001545595 |
| 648 | 419904 | 272097792 | 25.4558441  | 8.6534974 | .001543210 |
| 649 | 421201 | 273359449 | 25.4754784  | 8.6579465 | .001540832 |
| 650 | 422500 | 274625000 | 25.4950976  | 8.6623911 | .001538462 |
| 651 | 423801 | 275894451 | 25.5147016  | 8.6668310 | .001536098 |
| 652 | 425104 | 277167808 | 25.5342907  | 8.6712665 | .001533742 |
| 653 | 426409 | 278445077 | 25.5538647  | 8.6756974 | .001531394 |
| 654 | 427716 | 279726264 | 25.5734237  | 8.6801237 | .001529052 |
| 655 | 429025 | 281011375 | 25.5929678  | 8.6845456 | .001526718 |
| 656 | 430336 | 282300416 | 25.6124969  | 8.6889630 | .001524390 |
| 657 | 431649 | 283593393 | 25.6320112  | 8.6933759 | .001522070 |
| 658 | 432964 | 284890312 | 25.6515107  | 8.6977843 | .001519757 |
| 659 | 434281 | 286191179 | 25.6709953  | 8.7021882 | .001517451 |
| 660 | 435600 | 287496000 | 25.6904652  | 8.7065877 | .001515152 |
| 661 | 436921 | 288804781 | 25.7099203  | 8.7109827 | .001512859 |
| 662 | 438244 | 290117528 | 25.7293607  | 8.7153734 | .001510574 |
| 663 | 439569 | 291434247 | 25.7487864  | 8.7197596 | .001508296 |
| 664 | 440896 | 292754944 | 25.7681975  | 8.7241414 | .001506024 |
| 665 | 442225 | 294079625 | 25.7875939  | 8.7285187 | .001503759 |
| 666 | 443556 | 295408296 | 25.8069758  | 8.7328918 | .001501502 |
| 667 | 444889 | 296740963 | 25.8263431  | 8.7372604 | .001499250 |
| 668 | 446224 | 298077632 | 25.8456960  | 8.7416246 | .001497006 |
| 669 | 447561 | 299418309 | 25.8650343  | 8.7459846 | .001494768 |
| 670 | 448900 | 300763000 | 25.8843582  | 8.7503401 | .001492537 |
| 671 | 450241 | 302111711 | 25.9036677  | 8.7546913 | .001490313 |
| 672 | 451584 | 303464448 | 25.9229628  | 8.7590383 | .001488095 |
| 673 | 452929 | 304821217 | 25.9422435  | 8.7633809 | .001485884 |
| 674 | 454276 | 306182024 | 25.9615100  | 8.7677192 | .001483680 |
| 675 | 455625 | 307546875 | 25.9807621  | 8.7720532 | .001481481 |
| 676 | 456976 | 308915776 | 26.0000000  | 8.7763830 | .001479290 |
| 677 | 458329 | 310288733 | 26.0192237  | 8.7807084 | .001477105 |
| 678 | 459684 | 311665752 | 26.0384331  | 8.7850296 | .001474926 |
| 679 | 461041 | 313046839 | 26.0576284  | 8.7893466 | .001472754 |
| 680 | 462400 | 314432000 | 26.0768096  | 8.7936593 | .001470588 |
| 681 | 463761 | 315821241 | 26.0959767  | 8.7979679 | .001468429 |
| 682 | 465124 | 317214568 | 26.1151297  | 8.8022721 | .001466276 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 683 | 466489 | 318611987 | 26.1342687  | 8.8065722 | •001464129 |
| 684 | 467856 | 320013504 | 26.1533937  | 8.8108681 | •001461988 |
| 685 | 469225 | 321419125 | 26.1725047  | 8.8151598 | •001459854 |
| 686 | 470596 | 322828856 | 26.1916017  | 8.8194474 | •001457726 |
| 687 | 471969 | 324242703 | 26.2106848  | 8.8237307 | •001455604 |
| 688 | 473844 | 325660672 | 26.2297541  | 8.8280099 | •001453488 |
| 689 | 474721 | 327082769 | 26.2488095  | 8.8322850 | •001451379 |
| 690 | 476100 | 328509000 | 26.2678511  | 8.8365559 | •001449275 |
| 691 | 477481 | 329939371 | 26.2868789  | 8.8408227 | •001447178 |
| 692 | 478864 | 331873888 | 26.3058929  | 8.8450854 | •001445087 |
| 693 | 480249 | 332812557 | 26.3248932  | 8.8493440 | •001443001 |
| 694 | 481636 | 334255384 | 26.3438797  | 8.8535985 | •001440922 |
| 695 | 483025 | 335702375 | 26.3628527  | 8.8578489 | •001438849 |
| 696 | 484416 | 337153536 | 26.3818119  | 8.8620952 | •001436782 |
| 697 | 485809 | 338608873 | 26.4007576  | 8.8663375 | •001434720 |
| 698 | 487204 | 340068392 | 26.4196896  | 8.8705757 | •001432665 |
| 699 | 488601 | 341532099 | 26.4386081  | 8.8748099 | •001430615 |
| 700 | 490000 | 343000000 | 26.4575131  | 8.8790400 | •001428571 |
| 701 | 491401 | 344472101 | 26.4764046  | 8.8832661 | •001426534 |
| 702 | 492804 | 345948408 | 26.4952826  | 8.8874882 | •001424501 |
| 703 | 494209 | 347428927 | 26.5141472  | 8.8917063 | •001422475 |
| 704 | 495616 | 348913664 | 26.5329983  | 8.8959204 | •001420455 |
| 705 | 497025 | 350402625 | 26.5518361  | 8.9001304 | •001418440 |
| 706 | 498436 | 351895816 | 26.5706605  | 8.9043866 | •001416431 |
| 707 | 499849 | 353393243 | 26.5894716  | 8.9085387 | •001414427 |
| 708 | 501264 | 354894912 | 26.6082694  | 8.9127869 | •001412429 |
| 709 | 502681 | 356400829 | 26.6270539  | 8.9169311 | •001410437 |
| 710 | 504100 | 357911000 | 26.6458252  | 8.9211214 | •001408451 |
| 711 | 505521 | 359425431 | 26.6645833  | 8.9253078 | •001406470 |
| 712 | 506944 | 360944128 | 26.6833281  | 8.9294902 | •001404494 |
| 713 | 508369 | 362467097 | 26.7020598  | 8.9336687 | •001402525 |
| 714 | 509796 | 363994344 | 26.7207784  | 8.9378433 | •001400560 |
| 715 | 511225 | 365525875 | 26.7394839  | 8.9420140 | •001398601 |
| 716 | 512656 | 367061696 | 26.7581763  | 8.9461809 | •001396648 |
| 717 | 514089 | 368601813 | 26.7768557  | 8.9503438 | •001394700 |
| 718 | 515524 | 370146232 | 26.7955220  | 8.9545029 | •001392758 |
| 719 | 516961 | 371694959 | 26.8141754  | 8.9586581 | •001390821 |
| 720 | 518400 | 373248000 | 26.8328157  | 8.9628095 | •001388889 |
| 721 | 519841 | 374805361 | 26.8514432  | 8.9669570 | •001386963 |
| 722 | 521284 | 376367048 | 26.8700577  | 8.9711007 | •001385042 |
| 723 | 522729 | 377933067 | 26.8886593  | 8.9752406 | •001383126 |
| 724 | 524176 | 379503424 | 26.9072481  | 8.9793766 | •001381215 |
| 725 | 525625 | 381078125 | 26.9258240  | 8.9835089 | •001379310 |
| 726 | 527076 | 382657176 | 26.9443872  | 8.9876373 | •001377410 |
| 727 | 528529 | 384240583 | 26.9629375  | 8.9917620 | •001375516 |
| 728 | 529984 | 385828352 | 26.9814751  | 8.9958829 | •001373626 |
| 729 | 531441 | 387420489 | 27.0000000  | 9.0000000 | •001371742 |
| 730 | 532900 | 389017000 | 27.0185122  | 9.0041134 | •001369868 |
| 731 | 534361 | 390617891 | 27.0370117  | 9.0082229 | •001367989 |



| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 782 | 535824 | 892223168 | 27.0554985  | 9.0123288 | .001366120 |
| 783 | 537289 | 898882887 | 27.0739727  | 9.0164309 | .001364256 |
| 784 | 538756 | 895446904 | 27.0924344  | 9.0205293 | .001362398 |
| 785 | 540225 | 897065375 | 27.1108834  | 9.0246239 | .001360544 |
| 786 | 541696 | 898688256 | 27.1293199  | 9.0287149 | .001358696 |
| 787 | 543169 | 400315553 | 27.1477439  | 9.0328021 | .001356852 |
| 788 | 544644 | 401947272 | 27.1661554  | 9.0368857 | .001355014 |
| 789 | 546121 | 403583419 | 27.1845544  | 9.0409655 | .001353180 |
| 790 | 547600 | 405224000 | 27.2029410  | 9.0450417 | .001351351 |
| 791 | 549081 | 406869021 | 27.2213152  | 9.0491142 | .001349528 |
| 792 | 550564 | 408518488 | 27.2396769  | 9.0531831 | .001347709 |
| 793 | 552049 | 410172407 | 27.2580263  | 9.0572482 | .001345895 |
| 794 | 553536 | 411830784 | 27.2763634  | 9.0613098 | .001344086 |
| 795 | 555025 | 413493625 | 27.2946881  | 9.0653677 | .001342282 |
| 796 | 556516 | 415160986 | 27.3130006  | 9.0694220 | .001340483 |
| 797 | 558009 | 416832723 | 27.3313007  | 9.0734726 | .001338688 |
| 798 | 559504 | 418508992 | 27.3495887  | 9.0775197 | .001336898 |
| 799 | 561001 | 420189749 | 27.3678644  | 9.0815631 | .001335113 |
| 800 | 562500 | 421875000 | 27.3861279  | 9.0856030 | .001333333 |
| 801 | 564001 | 423564751 | 27.4043792  | 9.0896392 | .001331558 |
| 802 | 565504 | 425259008 | 27.4226184  | 9.0936719 | .001329787 |
| 803 | 567009 | 426957777 | 27.4408455  | 9.0977010 | .001328021 |
| 804 | 568516 | 428661064 | 27.4590604  | 9.1017265 | .001326260 |
| 805 | 570025 | 430368875 | 27.4772633  | 9.1057485 | .001324503 |
| 806 | 571536 | 432081216 | 27.4954542  | 9.1097669 | .001322751 |
| 807 | 573049 | 433798093 | 27.5136330  | 9.1137818 | .001321004 |
| 808 | 574564 | 435519512 | 27.5317998  | 9.1177931 | .001319261 |
| 809 | 576081 | 437245479 | 27.5499546  | 9.1218010 | .001317523 |
| 810 | 577600 | 438976000 | 27.5680975  | 9.1258053 | .001315789 |
| 811 | 579121 | 440711081 | 27.5862284  | 9.1298061 | .001314060 |
| 812 | 580644 | 442450728 | 27.6043475  | 9.1338034 | .001312336 |
| 813 | 582169 | 444194947 | 27.6224546  | 9.1377971 | .001310616 |
| 814 | 583696 | 445943744 | 27.6405499  | 9.1417874 | .001308901 |
| 815 | 585225 | 447697125 | 27.6586334  | 9.1457742 | .001307190 |
| 816 | 586756 | 449455096 | 27.6767050  | 9.1497576 | .001305483 |
| 817 | 588289 | 451217663 | 27.6947648  | 9.1537375 | .001303781 |
| 818 | 589824 | 452984832 | 27.7128129  | 9.1577139 | .001302083 |
| 819 | 591361 | 454756609 | 27.7308492  | 9.1616869 | .001300390 |
| 820 | 592900 | 456533000 | 27.7488739  | 9.1656565 | .001298701 |
| 821 | 594441 | 458314011 | 27.7668868  | 9.1696225 | .001297017 |
| 822 | 595984 | 460099648 | 27.7848880  | 9.1735852 | .001295337 |
| 823 | 597529 | 461889917 | 27.8028775  | 9.1775445 | .001293661 |
| 824 | 599076 | 463684824 | 27.8208555  | 9.1815003 | .001291990 |
| 825 | 600625 | 465484375 | 27.8388218  | 9.1854527 | .001290323 |
| 826 | 602176 | 467288576 | 27.8567766  | 9.1894018 | .001288660 |
| 827 | 603729 | 469097433 | 27.8747197  | 9.1933474 | .001287001 |
| 828 | 605284 | 470910952 | 27.8926514  | 9.1972897 | .001285347 |
| 829 | 606841 | 472729139 | 27.9105715  | 9.2012286 | .001283697 |
| 830 | 608400 | 474552000 | 27.9284801  | 9.2051641 | .001282051 |



| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 781 | 609961 | 476379541 | 27.9463772  | 9.2090962 | .001280410 |
| 782 | 611524 | 478211768 | 27.9642629  | 9.2180250 | .001278772 |
| 783 | 613089 | 480048687 | 27.9821372  | 9.2169505 | .001277139 |
| 784 | 614676 | 481890304 | 28.0000000  | 9.2208726 | .001275510 |
| 785 | 616225 | 483736625 | 28.0178515  | 9.2247914 | .001273885 |
| 786 | 617796 | 485587656 | 28.0356915  | 9.2287068 | .001272265 |
| 787 | 619369 | 487443403 | 28.0535203  | 9.2326189 | .001270648 |
| 788 | 620944 | 489303872 | 28.0713377  | 9.2365277 | .001269036 |
| 789 | 622521 | 491169069 | 28.0891438  | 9.2404333 | .001267427 |
| 790 | 624100 | 493039000 | 28.1069386  | 9.2443355 | .001265828 |
| 791 | 625681 | 494913671 | 28.1247222  | 9.2482344 | .001264223 |
| 792 | 627264 | 496793088 | 28.1424946  | 9.2521300 | .001262626 |
| 793 | 628849 | 498677257 | 28.1602557  | 9.2560224 | .001261034 |
| 794 | 630436 | 500566184 | 28.1780056  | 9.2599114 | .001259446 |
| 795 | 632025 | 502459875 | 28.1957444  | 9.2637973 | .001257862 |
| 796 | 633616 | 504358336 | 28.2134720  | 9.2676798 | .001256281 |
| 797 | 635209 | 506261573 | 28.2311884  | 9.2715592 | .001254705 |
| 798 | 636804 | 508169592 | 28.2488938  | 9.2754352 | .001253133 |
| 799 | 638401 | 510082899 | 28.2665881  | 9.2793081 | .001251564 |
| 800 | 640000 | 512000000 | 28.2842712  | 9.2831777 | .001250000 |
| 801 | 641601 | 513922401 | 28.3019484  | 9.2870440 | .001248439 |
| 802 | 643204 | 515849608 | 28.3196045  | 9.2909072 | .001246888 |
| 803 | 644809 | 517781627 | 28.3372546  | 9.2947671 | .001245330 |
| 804 | 646416 | 519718464 | 28.3548938  | 9.2986239 | .001243781 |
| 805 | 648025 | 521660125 | 28.3725219  | 9.3024775 | .001242236 |
| 806 | 649636 | 523606616 | 28.3901391  | 9.3063278 | .001240695 |
| 807 | 651249 | 525557943 | 28.4077454  | 9.3101750 | .001239157 |
| 808 | 652864 | 527514112 | 28.4253408  | 9.3140190 | .001237624 |
| 809 | 654481 | 529475129 | 28.4429253  | 9.3178599 | .001236094 |
| 810 | 656100 | 531441000 | 28.4604989  | 9.3216975 | .001234568 |
| 811 | 657721 | 533411731 | 28.4780617  | 9.3255320 | .001233046 |
| 812 | 659344 | 535387328 | 28.4956137  | 9.3293634 | .001231527 |
| 813 | 660969 | 537367797 | 28.5131549  | 9.3331916 | .001230012 |
| 814 | 662596 | 539353144 | 28.5306852  | 9.3370167 | .001228501 |
| 815 | 664225 | 541343375 | 28.5482048  | 9.3408386 | .001226994 |
| 816 | 665856 | 543338496 | 28.5657137  | 9.3446575 | .001225490 |
| 817 | 667489 | 545338513 | 28.5832119  | 9.3484731 | .001223990 |
| 818 | 669124 | 547343432 | 28.6006993  | 9.3522857 | .001222494 |
| 819 | 670761 | 549353259 | 28.6181760  | 9.3560952 | .001221001 |
| 820 | 672400 | 551368000 | 28.6356421  | 9.3599016 | .001219512 |
| 821 | 674041 | 553387661 | 28.6530976  | 9.3637049 | .001218027 |
| 822 | 675684 | 555412248 | 28.6705424  | 9.3675051 | .001216545 |
| 823 | 677329 | 557441767 | 28.6879766  | 9.3713022 | .001215067 |
| 824 | 678976 | 559476224 | 28.7054002  | 9.3750963 | .001213592 |
| 825 | 680625 | 561515625 | 28.7228132  | 9.3788873 | .001212121 |
| 826 | 682276 | 563559976 | 28.7402157  | 9.3826752 | .001210654 |
| 827 | 683929 | 565609283 | 28.7576077  | 9.3864600 | .001209190 |
| 828 | 685584 | 567663552 | 28.7749891  | 9.3902419 | .001207729 |
| 829 | 687241 | 569722789 | 28.7923601  | 9.3940206 | .001206272 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 830 | 688900 | 571787000 | 28·8097206  | 9·3977964 | ·001204819 |
| 831 | 690561 | 573856191 | 28·8270706  | 9·4015691 | ·001203369 |
| 832 | 692224 | 575930368 | 28·8444102  | 9·4053387 | ·001201923 |
| 833 | 693889 | 578009587 | 28·8617394  | 9·4091054 | ·001200480 |
| 834 | 695556 | 580093704 | 28·8790582  | 9·4128690 | ·001199041 |
| 835 | 697225 | 582182875 | 28·8963666  | 9·4166297 | ·001197605 |
| 836 | 698896 | 584277056 | 28·9136646  | 9·4203873 | ·001196172 |
| 837 | 700569 | 586376253 | 28·9309523  | 9·4241420 | ·001194743 |
| 838 | 702244 | 588480472 | 28·9482297  | 9·4278936 | ·001193317 |
| 839 | 703921 | 590589719 | 28·9654967  | 9·4316423 | ·001191895 |
| 840 | 705600 | 592704000 | 28·9827535  | 9·4353880 | ·001190476 |
| 841 | 707281 | 594823321 | 29·0000000  | 9·4391307 | ·001189061 |
| 842 | 708964 | 596947688 | 29·0172363  | 9·4428704 | ·001187648 |
| 843 | 710649 | 599077107 | 29·0344623  | 9·4466072 | ·001186240 |
| 844 | 712336 | 601211584 | 29·0516781  | 9·4503410 | ·001184834 |
| 845 | 714025 | 603351125 | 29·0688837  | 9·4540719 | ·001183432 |
| 846 | 715716 | 605495736 | 29·0860791  | 9·4577999 | ·001182033 |
| 847 | 717409 | 607645423 | 29·1032644  | 9·4615249 | ·001180638 |
| 848 | 719104 | 609800192 | 29·1204396  | 9·4652470 | ·001179245 |
| 849 | 720801 | 611960049 | 29·1376046  | 9·4689661 | ·001177856 |
| 850 | 722500 | 614125000 | 29·1547595  | 9·4726824 | ·001176471 |
| 851 | 724201 | 616295051 | 29·1719043  | 9·4763957 | ·001175088 |
| 852 | 725904 | 618470208 | 29·1890390  | 9·4801061 | ·001173709 |
| 853 | 727609 | 620650477 | 29·2061637  | 9·4838136 | ·001172333 |
| 854 | 729316 | 622835864 | 29·2232784  | 9·4875182 | ·001170960 |
| 855 | 731025 | 625026375 | 29·2403830  | 9·4912200 | ·001169591 |
| 856 | 732736 | 627222016 | 29·2574777  | 9·4949188 | ·001168224 |
| 857 | 734449 | 629422793 | 29·2745623  | 9·4986147 | ·001166861 |
| 858 | 736164 | 631628712 | 29·2916370  | 9·5023078 | ·001165501 |
| 859 | 737881 | 633839779 | 29·3087018  | 9·5059980 | ·001164144 |
| 860 | 739600 | 636056000 | 29·3257566  | 9·5096854 | ·001162791 |
| 861 | 741321 | 638277381 | 29·3428015  | 9·5133699 | ·001161440 |
| 862 | 743044 | 640503928 | 29·3598365  | 9·5170515 | ·001160093 |
| 863 | 744769 | 642735647 | 29·3768616  | 9·5207303 | ·001158749 |
| 864 | 746496 | 644972544 | 29·3938769  | 9·5244063 | ·001157407 |
| 865 | 748225 | 647214625 | 29·4108823  | 9·5280791 | ·001156069 |
| 866 | 749956 | 649461896 | 29·4278779  | 9·5317497 | ·001154734 |
| 867 | 751689 | 651714363 | 29·4448637  | 9·5354172 | ·001153403 |
| 868 | 753424 | 653972032 | 29·4618397  | 9·5390818 | ·001152074 |
| 869 | 755161 | 656234909 | 29·4788059  | 9·5427437 | ·001150748 |
| 870 | 756900 | 658503000 | 29·4957624  | 9·5464027 | ·001149425 |
| 871 | 758641 | 660776311 | 29·5127091  | 9·5500589 | ·001148106 |
| 872 | 760384 | 663054848 | 29·5296461  | 9·5537123 | ·001146789 |
| 873 | 762129 | 665338617 | 29·5465734  | 9·5573630 | ·001145475 |
| 874 | 763876 | 667627624 | 29·5634910  | 9·5610108 | ·001144165 |
| 875 | 765625 | 669921875 | 29·5803989  | 9·5646559 | ·001142857 |
| 876 | 767376 | 672221376 | 29·5972972  | 9·5682982 | ·001141553 |
| 877 | 769129 | 674526133 | 29·6141858  | 9·5719377 | ·001140251 |
| 878 | 770884 | 676836152 | 29·6310648  | 9·5755745 | ·001138952 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 879 | 772641 | 679151489 | 29.6479342  | 9.5792085 | .001187656 |
| 880 | 774400 | 681472000 | 29.6647939  | 9.5828397 | .001186364 |
| 881 | 776161 | 683797841 | 29.6816442  | 9.5864682 | .001185074 |
| 882 | 777924 | 686128968 | 29.6984848  | 9.5900939 | .001183787 |
| 883 | 779689 | 688465387 | 29.7153159  | 9.5937169 | .001182503 |
| 884 | 781456 | 690807104 | 29.7321375  | 9.5973373 | .001181222 |
| 885 | 783225 | 693154125 | 29.7489496  | 9.6009548 | .001129944 |
| 886 | 784996 | 695506456 | 29.7657521  | 9.6045696 | .001128668 |
| 887 | 786769 | 697864103 | 29.7825452  | 9.6081817 | .001127396 |
| 888 | 788544 | 700227072 | 29.7993289  | 9.6117911 | .001126126 |
| 889 | 790321 | 702595369 | 29.8161030  | 9.6153977 | .001124859 |
| 890 | 792100 | 704969000 | 29.8328678  | 9.6190017 | .001123596 |
| 891 | 793881 | 707347971 | 29.8496231  | 9.6226030 | .001122334 |
| 892 | 795664 | 709732288 | 29.8663690  | 9.6262016 | .001121076 |
| 893 | 797449 | 712121957 | 29.8831056  | 9.6297975 | .001119821 |
| 894 | 799236 | 714516984 | 29.8998328  | 9.6333907 | .001118568 |
| 895 | 801025 | 716917375 | 29.9165506  | 9.6369812 | .001117318 |
| 896 | 802816 | 719323136 | 29.9332591  | 9.6405690 | .001116071 |
| 897 | 804609 | 721734273 | 29.9499583  | 9.6441542 | .001114827 |
| 898 | 806404 | 724150792 | 29.9666481  | 9.6477367 | .001113586 |
| 899 | 808201 | 726572699 | 29.9833287  | 9.6513166 | .001112347 |
| 900 | 810000 | 729000000 | 30.0000000  | 9.6548938 | .001111111 |
| 901 | 811801 | 731432701 | 30.0166620  | 9.6584684 | .001109878 |
| 902 | 813604 | 733870808 | 30.0333148  | 9.6620403 | .001108647 |
| 903 | 815409 | 736314327 | 30.0499584  | 9.6656096 | .001107420 |
| 904 | 817216 | 738763264 | 30.0665928  | 9.6691762 | .001106195 |
| 905 | 819025 | 741217625 | 30.0832179  | 9.6727403 | .001104972 |
| 906 | 820836 | 743677416 | 30.0998339  | 9.6763017 | .001103753 |
| 907 | 822649 | 746142643 | 30.1164407  | 9.6798604 | .001102536 |
| 908 | 824464 | 748613312 | 30.1330383  | 9.6834166 | .001101322 |
| 909 | 826281 | 751089429 | 30.1496269  | 9.6869701 | .001100110 |
| 910 | 828100 | 753571000 | 30.1662063  | 9.6905211 | .001098901 |
| 911 | 829921 | 756058031 | 30.1827765  | 9.6940694 | .001097695 |
| 912 | 831744 | 758550528 | 30.1993377  | 9.6976151 | .001096491 |
| 913 | 833569 | 761048497 | 30.2158899  | 9.7011583 | .001095290 |
| 914 | 835396 | 763551944 | 30.2324329  | 9.7046989 | .001094092 |
| 915 | 837225 | 766060875 | 30.2489669  | 9.7082369 | .001092896 |
| 916 | 839056 | 768575296 | 30.2654919  | 9.7117723 | .001091703 |
| 917 | 840889 | 771095213 | 30.2820079  | 9.7153051 | .001090518 |
| 918 | 842724 | 773620632 | 30.2985148  | 9.7188354 | .001089325 |
| 919 | 844561 | 776151559 | 30.3150128  | 9.7223631 | .001088139 |
| 920 | 846400 | 778688000 | 30.3315018  | 9.7258883 | .001086957 |
| 921 | 848241 | 781229961 | 30.3479818  | 9.7294109 | .001085776 |
| 922 | 850084 | 783777448 | 30.3644529  | 9.7329309 | .001084599 |
| 923 | 851929 | 786330467 | 30.3809151  | 9.7364484 | .001083424 |
| 924 | 853776 | 788889024 | 39.3973683  | 9.7399634 | .001082251 |
| 925 | 855625 | 791453125 | 30.4138127  | 9.7434758 | .001081081 |
| 926 | 857476 | 794022776 | 30.4302481  | 9.7469857 | .001079914 |
| 927 | 859329 | 796597983 | 30.4466747  | 9.7504930 | .001078749 |

| No. | Square | Cube      | Square Root | Cube Root | Reciprocal |
|-----|--------|-----------|-------------|-----------|------------|
| 928 | 861184 | 799178752 | 80-4630924  | 9-7539979 | ·001077586 |
| 929 | 868041 | 801765089 | 80-4795013  | 9-7575002 | ·001076426 |
| 930 | 864900 | 804357000 | 80-4959014  | 9-7610001 | ·001075269 |
| 931 | 866761 | 806954491 | 80-5122926  | 9-7644974 | ·001074114 |
| 932 | 868624 | 809557568 | 80-5286750  | 9-7679922 | ·001072961 |
| 933 | 870489 | 812166237 | 80-5450487  | 9-7714845 | ·00107 811 |
| 934 | 872356 | 814780504 | 80-5614136  | 9-7749743 | ·001070664 |
| 935 | 874225 | 817400375 | 80-5777697  | 9-7784616 | ·001069519 |
| 936 | 876096 | 820025856 | 80-5941171  | 9-7819466 | ·001068376 |
| 937 | 877969 | 822656953 | 80-6104557  | 9-7854288 | ·001067236 |
| 938 | 879844 | 825293672 | 80-6267857  | 9-7889087 | ·001066098 |
| 939 | 881721 | 827936019 | 80-6431069  | 9-7923861 | ·001064963 |
| 940 | 883600 | 830584000 | 80-6594194  | 9-7958611 | ·001063830 |
| 941 | 885481 | 833237621 | 80-6757233  | 9-7993336 | ·001062699 |
| 942 | 887364 | 835896888 | 80-6920185  | 9-8028036 | ·001061571 |
| 943 | 889249 | 838561807 | 80-7083051  | 9-8062711 | ·001060445 |
| 944 | 891136 | 841232384 | 80-7245830  | 9-8097362 | ·001059322 |
| 945 | 893025 | 843908625 | 80-7408523  | 9-8131989 | ·001058201 |
| 946 | 894916 | 846590536 | 80-7571130  | 9-8166591 | ·001057082 |
| 947 | 896809 | 849278123 | 80-7733651  | 9-8201169 | ·001055966 |
| 948 | 898704 | 851971392 | 80-7896086  | 9-8235723 | ·001054852 |
| 949 | 900601 | 854670349 | 80-8058436  | 9-8270252 | ·00 053741 |
| 950 | 902500 | 857375000 | 80-8220700  | 9-8304757 | ·001052632 |
| 951 | 904401 | 860085351 | 80-8382879  | 9-8339238 | ·001051525 |
| 952 | 906304 | 862801408 | 80-8544972  | 9-8373695 | ·001050420 |
| 953 | 908209 | 865523177 | 80-8706981  | 9-8408127 | ·001049318 |
| 954 | 910116 | 868250664 | 80-8868904  | 9-8442536 | ·001048218 |
| 955 | 912025 | 870983875 | 80-9030743  | 9-8476920 | ·001047120 |
| 956 | 913936 | 873722816 | 80-9192497  | 9-8511280 | ·001046025 |
| 957 | 915849 | 876467493 | 80-9354166  | 9-8545617 | ·001044932 |
| 958 | 917764 | 879217912 | 80-9515751  | 9-8579929 | ·001043841 |
| 959 | 919681 | 881974079 | 80-9677251  | 9-8614218 | ·001042753 |
| 960 | 921600 | 884736000 | 80-9838668  | 9-8648483 | ·001041667 |
| 961 | 923521 | 887503681 | 81-0000000  | 9-8682724 | ·001040583 |
| 962 | 925444 | 890277128 | 81-0161248  | 9-8716941 | ·001039501 |
| 963 | 927369 | 893056347 | 81-0322413  | 9-8751135 | ·00 038422 |
| 964 | 929296 | 895841344 | 81-0483494  | 9-8785305 | ·001037344 |
| 965 | 931225 | 898632125 | 81-0644491  | 9-8819451 | ·001036269 |
| 966 | 933156 | 901428696 | 81-0805405  | 9-8853574 | ·001035197 |
| 967 | 935089 | 904231063 | 81-0966236  | 9-8887673 | ·001034126 |
| 968 | 937024 | 907039282 | 81-1126984  | 9-8921749 | ·001033058 |
| 969 | 938961 | 909853209 | 81-1287648  | 9-8955801 | ·001031992 |
| 970 | 940900 | 912673000 | 81-1448230  | 9-8989830 | ·001030928 |
| 971 | 942841 | 915498611 | 81-1608729  | 9-9023835 | ·001029866 |
| 972 | 944784 | 918330048 | 81-1769145  | 9-9057817 | ·001028807 |
| 973 | 946729 | 921167317 | 81-1929479  | 9-9091776 | ·001027749 |
| 974 | 948676 | 924010424 | 81-2089731  | 9-9125712 | ·001026694 |
| 975 | 950625 | 926859375 | 81-2249900  | 9-9159624 | ·001025641 |
| 976 | 952576 | 929714176 | 81-2409987  | 9-9193513 | ·001024590 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 977  | 954529  | 932574833  | 81.2569992  | 9.9227379  | .001023541  |
| 978  | 956484  | 935441352  | 81.2729915  | 9.9261222  | .001022495  |
| 979  | 958441  | 938318739  | 81.2889757  | 9.9295042  | .001021450  |
| 980  | 960400  | 941192000  | 81.3049517  | 9.9328839  | .001020408  |
| 981  | 962361  | 944076141  | 81.3209195  | 9.9362613  | .001019368  |
| 982  | 964324  | 946966168  | 81.3368792  | 9.9396363  | .001018380  |
| 983  | 966289  | 949862087  | 81.3528308  | 9.9430092  | .001017294  |
| 984  | 968256  | 952763904  | 81.3687743  | 9.9463797  | .001016260  |
| 985  | 970225  | 955671625  | 81.3847097  | 9.9497479  | .001015228  |
| 986  | 972196  | 958585256  | 81.4006369  | 9.9531138  | .001014199  |
| 987  | 974169  | 961504803  | 81.4165561  | 9.9564775  | .001013171  |
| 988  | 976144  | 964430272  | 81.4324678  | 9.9598389  | .001012146  |
| 989  | 978121  | 967361669  | 81.4483704  | 9.9631981  | .001011122  |
| 990  | 980100  | 970299000  | 81.4642654  | 9.9665549  | .001010101  |
| 991  | 982081  | 973242271  | 81.4801525  | 9.9699095  | .001009082  |
| 992  | 984064  | 976191488  | 81.4960315  | 9.9732619  | .001008065  |
| 993  | 986049  | 979146657  | 81.5119025  | 9.9766120  | .001007049  |
| 994  | 988036  | 982107784  | 81.5277655  | 9.9799599  | .001006036  |
| 995  | 990025  | 985074875  | 81.5436206  | 9.9833055  | .001005025  |
| 996  | 992016  | 988047936  | 81.5594677  | 9.9866488  | .001004016  |
| 997  | 994009  | 991026973  | 81.5753068  | 9.9899900  | .001003009  |
| 998  | 996004  | 994011992  | 81.5911380  | 9.9933289  | .001002004  |
| 999  | 998001  | 997002999  | 81.6069613  | 9.9966656  | .001001001  |
| 1000 | 1000000 | 1000000000 | 81.6227766  | 10.0000000 | .001000000  |
| 1001 | 1002001 | 1003003001 | 81.6385840  | 10.0033322 | .0009990010 |
| 1002 | 1004004 | 1006012008 | 81.6543836  | 10.0066622 | .0009980040 |
| 1003 | 1006009 | 1009027027 | 81.6701752  | 10.0099899 | .0009970090 |
| 1004 | 1008016 | 1012048064 | 81.6859590  | 10.0133155 | .0009960159 |
| 1005 | 1010025 | 1015075125 | 81.7017349  | 10.0166389 | .0009950249 |
| 1006 | 1012036 | 1018108216 | 81.7175030  | 10.0199601 | .0009940358 |
| 1007 | 1014049 | 1021147343 | 81.7332633  | 10.0232791 | .0009930487 |
| 1008 | 1016064 | 1024192512 | 81.7490157  | 10.0265958 | .0009920635 |
| 1009 | 1018081 | 1027243729 | 81.7647603  | 10.0299104 | .0009910803 |
| 1010 | 1020100 | 1030301000 | 81.7804972  | 10.0332228 | .0009900990 |
| 1011 | 1022121 | 1033364331 | 81.7962262  | 10.0365330 | .0009891197 |
| 1012 | 1024144 | 1036433728 | 81.8119474  | 10.0398410 | .0009881423 |
| 1013 | 1026169 | 1039509197 | 81.8276609  | 10.0431469 | .0009871668 |
| 1014 | 1028196 | 1042590744 | 81.8433666  | 10.0464506 | .0009861933 |
| 1015 | 1030225 | 1045678375 | 81.8590646  | 10.0497521 | .0009852217 |
| 1016 | 1032256 | 1048772096 | 81.8747549  | 10.0530514 | .0009842520 |
| 1017 | 1034289 | 1051871913 | 81.8904374  | 10.0563485 | .0009832842 |
| 1018 | 1036324 | 1054977832 | 81.9061123  | 10.0596435 | .0009823183 |
| 1019 | 1038361 | 1058089859 | 81.9217794  | 10.0629364 | .0009813543 |
| 1020 | 1040400 | 1061208000 | 81.9374388  | 10.0662271 | .0009803922 |
| 1021 | 1042441 | 1064332261 | 81.9530906  | 10.0695156 | .0009794319 |
| 1022 | 1044484 | 1067462648 | 81.9687347  | 10.0728020 | .0009784736 |
| 1023 | 1046529 | 1070599167 | 81.9843712  | 10.0760863 | .0009775171 |
| 1024 | 1048576 | 1073741824 | 82.0000000  | 10.0793684 | .0009765625 |
| 1025 | 1050625 | 1076890625 | 82.0156212  | 10.0826484 | .0009756098 |

| No.  | Square  | Cube        | Square Root | Cube Root  | Reciprocal  |
|------|---------|-------------|-------------|------------|-------------|
| 1026 | 1052676 | 1080045576  | 32.0312348  | 10.0859262 | .0009746589 |
| 1027 | 1054729 | 1083206683  | 32.0468407  | 10.0892019 | .0009737098 |
| 1028 | 1056784 | 1086373952  | 32.0624391  | 10.0924755 | .0009727626 |
| 1029 | 1058841 | 1089547389  | 32.0780298  | 10.0957469 | .0009718173 |
| 1030 | 1060900 | 1092727000  | 32.0936131  | 10.0990163 | .0009708738 |
| 1031 | 1062961 | 1095912791  | 32.1091887  | 10.1022835 | .0009699321 |
| 1032 | 1065024 | 1099104768  | 32.1247568  | 10.1055487 | .0009689922 |
| 1033 | 1067089 | 1102302937  | 32.1403173  | 10.1088117 | .0009680542 |
| 1034 | 1069156 | 1105507304  | 32.1558704  | 10.1120726 | .0009671180 |
| 1035 | 1071225 | 1108717875  | 32.1714159  | 10.1153314 | .0009661836 |
| 1036 | 1073296 | 1111934656  | 32.1869539  | 10.1185882 | .0009652510 |
| 1037 | 1075369 | 1115157653  | 32.2024844  | 10.1218428 | .0009643202 |
| 1038 | 1077444 | 1118386872  | 32.2180074  | 10.1250953 | .0009633911 |
| 1039 | 1079521 | 1121622319  | 32.2335229  | 10.1283457 | .0009624639 |
| 1040 | 1081600 | 1124864000  | 32.2490310  | 10.1315941 | .0009615385 |
| 1041 | 1083681 | 1128111921  | 32.2645316  | 10.1348403 | .0009606148 |
| 1042 | 1085764 | 1131366088  | 32.2800248  | 10.1380845 | .0009596929 |
| 1043 | 1087849 | 1134626507  | 32.2955105  | 10.1413266 | .0009587728 |
| 1044 | 1089936 | 1137893184  | 32.3109888  | 10.1445667 | .0009578544 |
| 1045 | 1092025 | 1141166125  | 32.3264598  | 10.1478017 | .0009569378 |
| 1046 | 1094116 | 1144445336  | 32.3419233  | 10.1510406 | .0009560229 |
| 1047 | 1096209 | 1147730823  | 32.3573794  | 10.1542744 | .0009551098 |
| 1048 | 1098304 | 1151022592  | 32.3728281  | 10.1575062 | .0009541985 |
| 1049 | 1100401 | 1154320649  | 32.3882695  | 10.1607359 | .0009532888 |
| 1050 | 1102500 | 1157625000  | 32.4037035  | 10.1639636 | .0009523810 |
| 1051 | 1104601 | 1160935651  | 32.4191301  | 10.1671893 | .0009514748 |
| 1052 | 1106704 | 1164252608  | 32.4345495  | 10.1704129 | .0009505703 |
| 1053 | 1108809 | 1167575877  | 32.4499615  | 10.1736344 | .0009496676 |
| 1054 | 1110916 | 1170905464  | 32.4653662  | 10.1768539 | .0009487666 |
| 1055 | 1113025 | 1174241375  | 32.4807635  | 10.1800714 | .0009478673 |
| 1056 | 1115136 | 1177583616  | 32.4961536  | 10.1832868 | .0009469697 |
| 1057 | 1117249 | 1180932193  | 32.5115364  | 10.1865002 | .0009460738 |
| 1058 | 1119364 | 1184287112  | 32.5269119  | 10.1897116 | .0009451796 |
| 1059 | 1121481 | 1187648379  | 32.5422802  | 10.1929209 | .0009442871 |
| 1060 | 1123600 | 1191016000  | 32.5576412  | 10.1961283 | .0009433962 |
| 1061 | 1125721 | 1194389981  | 32.5729949  | 10.1993386 | .0009425071 |
| 1062 | 1127844 | 11977770328 | 32.5883415  | 10.2025369 | .0009416196 |
| 1063 | 1129969 | 1201157047  | 32.6036807  | 10.2057382 | .0009407338 |
| 1064 | 1132096 | 1204550144  | 32.6190129  | 10.2089375 | .0009398496 |
| 1065 | 1134225 | 1207949625  | 32.6343377  | 10.2121347 | .0009389671 |
| 1066 | 1136356 | 1211355496  | 32.6496554  | 10.2153300 | .0009380863 |
| 1067 | 1138489 | 1214767763  | 32.6649659  | 10.2185233 | .0009372071 |
| 1068 | 1140624 | 1218186432  | 32.6802693  | 10.2217146 | .0009363296 |
| 1069 | 1142761 | 1221611509  | 32.6955654  | 10.2249039 | .0009354537 |
| 1070 | 1144900 | 1225043000  | 32.7108544  | 10.2280912 | .0009345794 |
| 1071 | 1147041 | 1228480911  | 32.7261363  | 10.2312766 | .0009337068 |
| 1072 | 1149184 | 1231925248  | 32.7414111  | 10.2344599 | .0009328358 |
| 1073 | 1151329 | 1235376017  | 32.7566787  | 10.2376413 | .0009319664 |
| 1074 | 1153476 | 1238833224  | 32.7719392  | 10.2408207 | .0009310987 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1075 | 1155625 | 1242296875 | 32.7871926  | 10.2439981 | .0009802326 |
| 1076 | 1157776 | 1245766976 | 32.8024389  | 10.2471785 | .0009293680 |
| 1077 | 1159929 | 1249243533 | 32.8176782  | 10.2503470 | .0009285051 |
| 1078 | 1162084 | 1252726552 | 32.8329103  | 10.2535186 | .0009276488 |
| 1079 | 1164241 | 1256216039 | 32.8481354  | 10.2566881 | .0009267841 |
| 1080 | 1166400 | 1259712000 | 32.8633535  | 10.2598557 | .0009259259 |
| 1081 | 1168561 | 1263214441 | 32.8785644  | 10.2630213 | .0009250694 |
| 1082 | 1170724 | 1266723368 | 32.8937684  | 10.2661850 | .0009242144 |
| 1083 | 1172889 | 1270238787 | 32.9089653  | 10.2693467 | .0009233610 |
| 1084 | 1175056 | 1273760704 | 32.9241553  | 10.2725065 | .0009225092 |
| 1085 | 1177225 | 1277289125 | 32.9393382  | 10.2756644 | .0009216590 |
| 1086 | 1179396 | 1280824056 | 32.9545141  | 10.2788203 | .0009208108 |
| 1087 | 1181569 | 1284365503 | 32.9696830  | 10.2819743 | .0009199632 |
| 1088 | 1183744 | 1287913472 | 32.9848450  | 10.2851264 | .0009191176 |
| 1089 | 1185921 | 1291467969 | 33.0000000  | 10.2882765 | .0009182736 |
| 1090 | 1188100 | 1295029000 | 33.0151480  | 10.2914247 | .0009174312 |
| 1091 | 1190281 | 1298596571 | 33.0302891  | 10.2945709 | .0009165908 |
| 1092 | 1192464 | 1302170688 | 33.0454233  | 10.2977153 | .0009157509 |
| 1093 | 1194649 | 1305751357 | 33.0605505  | 10.3008577 | .0009149131 |
| 1094 | 1196836 | 1309338584 | 33.0756708  | 10.3039982 | .0009140768 |
| 1095 | 1199025 | 1312932375 | 33.0907842  | 10.3071368 | .0009132420 |
| 1096 | 1201216 | 1316532736 | 33.1058907  | 10.3102735 | .0009124088 |
| 1097 | 1203409 | 1320139673 | 33.1209903  | 10.3134083 | .0009115770 |
| 1098 | 1205604 | 1323753192 | 33.1360830  | 10.3165411 | .0009107468 |
| 1099 | 1207801 | 1327373209 | 33.1511689  | 10.3196721 | .0009099181 |
| 1100 | 1210000 | 1331000000 | 33.1662479  | 10.3228012 | .0009090909 |
| 1101 | 1212201 | 1334633301 | 33.1813260  | 10.3259284 | .0009082652 |
| 1102 | 1214404 | 1338273208 | 33.1963853  | 10.3290537 | .0009074410 |
| 1103 | 1216609 | 1341919727 | 33.2114438  | 10.3321770 | .0009066188 |
| 1104 | 1218816 | 1345572864 | 33.2264955  | 10.3352985 | .0009057971 |
| 1105 | 1221025 | 1349232625 | 33.2415403  | 10.3384181 | .0009049774 |
| 1106 | 1223236 | 1352899016 | 33.2565783  | 10.3415358 | .0009041591 |
| 1107 | 1225449 | 1356572043 | 33.2716095  | 10.3446517 | .0009033424 |
| 1108 | 1227664 | 1360251712 | 33.2866339  | 10.3477657 | .0009025271 |
| 1109 | 1229881 | 1363938029 | 33.3016516  | 10.3508778 | .0009017133 |
| 1110 | 1232100 | 1367631000 | 33.3166625  | 10.3539880 | .0009009009 |
| 1111 | 1234321 | 1371330631 | 33.3316666  | 10.3570964 | .0009000900 |
| 1112 | 1236544 | 1375036928 | 33.3466640  | 10.3602029 | .0008992806 |
| 1113 | 1238769 | 1378749897 | 33.3616546  | 10.3633076 | .0008984726 |
| 1114 | 1240996 | 1382469544 | 33.3766385  | 10.3664103 | .0008976661 |
| 1115 | 1243225 | 1386195875 | 33.3916157  | 10.3695113 | .0008968610 |
| 1116 | 1245456 | 1389928896 | 33.4065862  | 10.3726103 | .0008960578 |
| 1117 | 1247689 | 1393668613 | 33.4215499  | 10.3757076 | .0008952551 |
| 1118 | 1249924 | 1397415032 | 33.4365070  | 10.3788030 | .0008944544 |
| 1119 | 1252161 | 1401168159 | 33.4514573  | 10.3818965 | .0008936550 |
| 1120 | 1254400 | 1404928000 | 33.4664011  | 10.3849882 | .0008928571 |
| 1121 | 1256641 | 1408694561 | 33.4813381  | 10.3880781 | .0008920607 |
| 1122 | 1258884 | 1412467848 | 33.4962684  | 10.3911661 | .0008912656 |
| 1123 | 1261129 | 1416247867 | 33.5111921  | 10.3942523 | .0008904720 |



| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1124 | 1263376 | 1420034624 | 33.5261092  | 10.3978366 | .0008896797 |
| 1125 | 1265625 | 1423828125 | 33.5410196  | 10.4004192 | .0008888889 |
| 1126 | 1267876 | 1427628376 | 33.5559234  | 10.4034999 | .0008880995 |
| 1127 | 1270129 | 1431435383 | 33.5708206  | 10.4065787 | .0008873114 |
| 1128 | 1272384 | 1435249152 | 33.5857112  | 10.4096557 | .0008865248 |
| 1129 | 1274641 | 1439069689 | 33.6005952  | 10.4127310 | .0008857396 |
| 1130 | 1276900 | 1442897000 | 33.6154726  | 10.4158044 | .0008849558 |
| 1131 | 1279161 | 1446731091 | 33.6303484  | 10.4188760 | .0008841733 |
| 1132 | 1281424 | 1450571968 | 33.6452077  | 10.4219458 | .0008833922 |
| 1133 | 1283689 | 1454419637 | 33.6600653  | 10.4250138 | .0008826125 |
| 1134 | 1285956 | 1458274104 | 33.6749165  | 10.4280800 | .0008818342 |
| 1135 | 1288225 | 1462135375 | 33.6897610  | 10.4311443 | .0008810573 |
| 1136 | 1290496 | 1466003456 | 33.7045991  | 10.4342069 | .0008802817 |
| 1137 | 1292769 | 1469878353 | 33.7194306  | 10.4372677 | .0008795075 |
| 1138 | 1295044 | 1473760072 | 33.7342556  | 10.4403267 | .0008787346 |
| 1139 | 1297321 | 1477648619 | 33.7490741  | 10.4433839 | .0008779681 |
| 1140 | 1299600 | 1481544000 | 33.7638860  | 10.4464393 | .0008771930 |
| 1141 | 1301881 | 1485446221 | 33.7786915  | 10.4494929 | .0008764242 |
| 1142 | 1304164 | 1489355288 | 33.7934905  | 10.4525448 | .0008756567 |
| 1143 | 1306449 | 1493271207 | 33.8082830  | 10.4555948 | .0008748903 |
| 1144 | 1308736 | 1497193984 | 33.8230691  | 10.4586431 | .0008741259 |
| 1145 | 1311025 | 1501123625 | 33.8378486  | 10.4616896 | .0008733624 |
| 1146 | 1313316 | 1505060186 | 33.8526218  | 10.4647343 | .0008726003 |
| 1147 | 1315609 | 1509003523 | 33.8673884  | 10.4677773 | .0008718396 |
| 1148 | 1317904 | 1512953792 | 33.8821487  | 10.4708185 | .0008710801 |
| 1149 | 1320201 | 1516910949 | 33.8969025  | 10.4738579 | .0008703220 |
| 1150 | 1322500 | 1520875000 | 33.9116499  | 10.4768955 | .0008695652 |
| 1151 | 1324801 | 1524845951 | 33.9263909  | 10.4799314 | .0008688097 |
| 1152 | 1327104 | 1528823808 | 33.9411255  | 10.4829656 | .0008680556 |
| 1153 | 1329409 | 1532808577 | 33.9558537  | 10.4859980 | .0008673027 |
| 1154 | 1331716 | 1536800264 | 33.9705755  | 10.4890286 | .0008665511 |
| 1155 | 1334025 | 1540798875 | 33.9852910  | 10.4920575 | .0008658009 |
| 1156 | 1336336 | 1544804416 | 34.0000000  | 10.4950847 | .0008650519 |
| 1157 | 1338649 | 1548816893 | 34.0147027  | 10.4981101 | .0008643042 |
| 1158 | 1340964 | 1552836312 | 34.0293990  | 10.5011337 | .0008635579 |
| 1159 | 1343281 | 1556862679 | 34.0440890  | 10.5041556 | .0008628128 |
| 1160 | 1345600 | 1560896000 | 34.0587727  | 10.5071757 | .0008620690 |
| 1161 | 1347921 | 1564936281 | 34.0734501  | 10.5101942 | .0008613264 |
| 1162 | 1350244 | 1568983528 | 34.0881211  | 10.5132109 | .0008605852 |
| 1163 | 1352569 | 1573037747 | 34.1027858  | 10.5162259 | .0008598452 |
| 1164 | 1354896 | 1577098944 | 34.1174442  | 10.5192391 | .0008591065 |
| 1165 | 1357225 | 1581167125 | 34.1320963  | 10.5222506 | .0008583691 |
| 1166 | 1359556 | 1585242296 | 34.1467422  | 10.5252604 | .0008576329 |
| 1167 | 1361889 | 1589324463 | 34.1613817  | 10.5282685 | .0008568980 |
| 1168 | 1364224 | 1593413632 | 34.1760150  | 10.5312749 | .0008561644 |
| 1169 | 1366561 | 1597509809 | 34.1906420  | 10.5342795 | .0008554320 |
| 1170 | 1368900 | 1601613000 | 34.2052627  | 10.5372825 | .0008547009 |
| 1171 | 1371241 | 1605723211 | 34.2198773  | 10.5402837 | .0008539710 |
| 1172 | 1373584 | 1609840448 | 34.2344855  | 10.5432832 | .0008532423 |



| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1173 | 1375929 | 1613964717 | 34-2496875  | 10-5462810 | ·0005525149 |
| 1174 | 1378276 | 1618096024 | 34-2636834  | 10-5492771 | ·0005517888 |
| 1175 | 1380625 | 1622234375 | 34-2782730  | 10-5522715 | ·0005510638 |
| 1176 | 1382976 | 1626379776 | 34-2928564  | 10-5552642 | ·0005503401 |
| 1177 | 1385329 | 1630532233 | 34-3074386  | 10-5582552 | ·0005496177 |
| 1178 | 1387684 | 1634691752 | 34-3220446  | 10-5612445 | ·0005488964 |
| 1179 | 1390041 | 1638858339 | 34-3365694  | 10-5642322 | ·0005481764 |
| 1180 | 1392400 | 1643032000 | 34-3511281  | 10-5672181 | ·0005474576 |
| 1181 | 1394761 | 1647212741 | 34-3656805  | 10-5702024 | ·0005467401 |
| 1182 | 1397124 | 1651400568 | 34-3802268  | 10-5731849 | ·0005460287 |
| 1183 | 1399489 | 1655595487 | 34-3947670  | 10-5761658 | ·0005453085 |
| 1184 | 1401856 | 1659797504 | 34-4093011  | 10-5791449 | ·0005445946 |
| 1185 | 1404225 | 1664006625 | 34-4238289  | 10-5821225 | ·0005438819 |
| 1186 | 1406596 | 1668222856 | 34-4383507  | 10-5850983 | ·0005431703 |
| 1187 | 1408969 | 1672446203 | 34-4528663  | 10-5880725 | ·0005424600 |
| 1188 | 1411344 | 1676676672 | 34-4673759  | 10-5910450 | ·0005417508 |
| 1189 | 1413721 | 1680914269 | 34-4818793  | 10-5940158 | ·0005410429 |
| 1190 | 1416100 | 1685159000 | 34-4963766  | 10-5969850 | ·0005403361 |
| 1191 | 1418481 | 1689410871 | 34-5108678  | 10-5999525 | ·0005396306 |
| 1192 | 1420864 | 1693669888 | 34-5253530  | 10-6029184 | ·0005389262 |
| 1193 | 1423249 | 1697936057 | 34-5398321  | 10-6058826 | ·0005382230 |
| 1194 | 1425636 | 1702209384 | 34-5543051  | 10-6088451 | ·0005375209 |
| 1195 | 1428025 | 1706489875 | 34-5687720  | 10-6118060 | ·0005368201 |
| 1196 | 1430416 | 1710777536 | 34-5832329  | 10-6147652 | ·0005361204 |
| 1197 | 1432809 | 1715072373 | 34-5976879  | 10-6177228 | ·0005354219 |
| 1198 | 1435204 | 1719374392 | 34-6121866  | 10-6206788 | ·0005347245 |
| 1199 | 1437601 | 1723683599 | 34-6265794  | 10-6236331 | ·0005340284 |
| 1200 | 1440000 | 1728000000 | 34-6410162  | 10-6265857 | ·0005333338 |
| 1201 | 1442401 | 1732323601 | 34-6554469  | 10-6295367 | ·0005326396 |
| 1202 | 1444804 | 1736654408 | 34-6698716  | 10-6324860 | ·0005319468 |
| 1203 | 1447209 | 1740992427 | 34-6842904  | 10-6354338 | ·0005312552 |
| 1204 | 1449616 | 1745337664 | 34-6987031  | 10-6383799 | ·0005305648 |
| 1205 | 1452025 | 1749690125 | 34-7131099  | 10-6413244 | ·0005298755 |
| 1206 | 1454436 | 1754049816 | 34-7275107  | 10-6442672 | ·0005291874 |
| 1207 | 1456849 | 1758416743 | 34-7419055  | 10-6472085 | ·0005285004 |
| 1208 | 1459264 | 1762790912 | 34-7562944  | 10-6501480 | ·0005278146 |
| 1209 | 1461681 | 1767172329 | 34-7706773  | 10-6530860 | ·0005271299 |
| 1210 | 1464100 | 1771561000 | 34-7850543  | 10-6560223 | ·0005264468 |
| 1211 | 1466521 | 1775956931 | 34-7994253  | 10-6589570 | ·0005257638 |
| 1212 | 1468944 | 1780360128 | 34-8137904  | 10-6618902 | ·0005250825 |
| 1213 | 1471369 | 1784770597 | 34-8281495  | 10-6648217 | ·0005244028 |
| 1214 | 1473796 | 1789188344 | 34-8425028  | 10-6677516 | ·0005237232 |
| 1215 | 1476225 | 1793613375 | 34-8568501  | 10-6706799 | ·0005230458 |
| 1216 | 1478656 | 1798045696 | 34-8711915  | 10-6736066 | ·0005223684 |
| 1217 | 1481089 | 1802485313 | 34-8855271  | 10-6765317 | ·0005216927 |
| 1218 | 1483524 | 1806932232 | 34-8998567  | 10-6794552 | ·0005210181 |
| 1219 | 1485961 | 1811386459 | 34-9141805  | 10-6823771 | ·0005203445 |
| 1220 | 1488400 | 1815848000 | 34-9284984  | 10-6852973 | ·0005196721 |
| 1221 | 1490841 | 1820316861 | 34-9428104  | 10-6882160 | ·0005190008 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1222 | 1498284 | 1824798048 | 34.9571166  | 10.6911331 | .0008183306 |
| 1228 | 1495729 | 1829276567 | 34.9714169  | 10.6940486 | .0008176615 |
| 1224 | 1498176 | 1883767424 | 34.9857114  | 10.6969625 | .0008169985 |
| 1225 | 1500625 | 1888265625 | 35.0000000  | 10.6998748 | .0008163265 |
| 1226 | 1503076 | 1842771176 | 35.0142828  | 10.7027855 | .0008156607 |
| 1227 | 1505529 | 1847284083 | 35.0285598  | 10.7056947 | .0008149959 |
| 1228 | 1507984 | 1851804352 | 35.0428309  | 10.7086023 | .0008143322 |
| 1229 | 1510441 | 1856331989 | 35.0570963  | 10.7115083 | .0008136696 |
| 1280 | 1512900 | 1860867000 | 35.0713558  | 10.7144127 | .0008130081 |
| 1281 | 1515361 | 1865409391 | 35.0856096  | 10.7173155 | .0008123477 |
| 1282 | 1517824 | 1869959168 | 35.0998575  | 10.7202168 | .0008116888 |
| 1288 | 1520289 | 1874516337 | 35.1140997  | 10.7231165 | .0008110300 |
| 1284 | 1522756 | 1879080904 | 35.1283361  | 10.7260146 | .0008103728 |
| 1285 | 1525225 | 1883652875 | 35.1425668  | 10.7289112 | .0008097166 |
| 1286 | 1527696 | 1888232256 | 35.1567917  | 10.7318062 | .0008090615 |
| 1287 | 1530169 | 1892819053 | 35.1710108  | 10.7346997 | .0008084074 |
| 1288 | 1532644 | 1897413272 | 35.1852242  | 10.7375916 | .0008077544 |
| 1289 | 1535121 | 1902014919 | 35.1994318  | 10.7404819 | .0008071025 |
| 1240 | 1537600 | 1906624000 | 35.2136337  | 10.7433707 | .0008064516 |
| 1241 | 1540081 | 1911240521 | 35.2278299  | 10.7462579 | .0008058018 |
| 1242 | 1542564 | 1915864488 | 35.2420204  | 10.7491436 | .0008051530 |
| 1248 | 1545049 | 1920495907 | 35.2562051  | 10.7520277 | .0008045052 |
| 1244 | 1547536 | 1925134784 | 35.2703842  | 10.8549103 | .0008038585 |
| 1245 | 1550025 | 1929781125 | 35.2845575  | 10.7577913 | .0008032129 |
| 1246 | 1552516 | 1934434936 | 35.2987252  | 10.7606708 | .0008025682 |
| 1247 | 1555009 | 1939096223 | 35.3128872  | 10.7635488 | .0008019246 |
| 1248 | 1557504 | 1943764992 | 35.3270435  | 10.7664252 | .0008012821 |
| 1249 | 1560001 | 1948441249 | 35.3411941  | 10.7693001 | .0008006405 |
| 1250 | 1562500 | 1953125000 | 35.3553391  | 10.7721735 | .0008000000 |
| 1251 | 1565001 | 1957816251 | 35.3694784  | 10.7750453 | .0007993605 |
| 1252 | 1567504 | 1962515008 | 35.3836120  | 10.7779156 | .0007987220 |
| 1253 | 1570009 | 1967221277 | 35.3977400  | 10.7807843 | .0007980846 |
| 1254 | 1572516 | 1971935064 | 35.4118624  | 10.7836516 | .0007974482 |
| 1255 | 1575025 | 1976656375 | 35.4259792  | 10.7865173 | .0007968127 |
| 1256 | 1577536 | 1981385216 | 35.4400903  | 10.7893815 | .0007961783 |
| 1257 | 1580049 | 1986121593 | 35.4541958  | 10.7922441 | .0007955449 |
| 1258 | 1582564 | 1990865512 | 35.4682957  | 10.7951053 | .0007949126 |
| 1259 | 1585081 | 1995616979 | 35.4823900  | 10.7979649 | .0007942812 |
| 1260 | 1587600 | 2000376000 | 35.4964787  | 10.8008230 | .0007936508 |
| 1261 | 1590121 | 2005142581 | 35.5105618  | 10.8036797 | .0007930214 |
| 1262 | 1592644 | 2009916728 | 35.5246393  | 10.8065348 | .0007923930 |
| 1263 | 1595169 | 2014698447 | 35.5387113  | 10.8093884 | .0007917656 |
| 1264 | 1597696 | 2019487744 | 35.5527777  | 10.8122404 | .0007911392 |
| 1265 | 1600225 | 2024284625 | 35.5668385  | 10.8150909 | .0007905138 |
| 1266 | 1602756 | 2029089096 | 35.5808937  | 10.8179400 | .0007898894 |
| 1267 | 1605289 | 2033901163 | 35.5949434  | 10.8207876 | .0007892660 |
| 1268 | 1607824 | 2038720832 | 35.6089876  | 10.8236336 | .0007886435 |
| 1269 | 1610361 | 2043548109 | 35.6230262  | 10.8264782 | .0007880221 |
| 1270 | 1612900 | 2048383000 | 35.6370593  | 10.8293213 | .0007874016 |

| No.  | Square  | Cube        | Square Root | Cube Root  | Reciprocal  |
|------|---------|-------------|-------------|------------|-------------|
| 1271 | 1615441 | 2053225511  | 35.6510869  | 10.8321629 | .0007867821 |
| 1272 | 1617984 | 2058075648  | 35.6651090  | 10.8350030 | .0007861685 |
| 1273 | 1620529 | 2062933417  | 35.6791255  | 10.8378416 | .0007855460 |
| 1274 | 1623076 | 2067798824  | 35.6931366  | 10.8406788 | .0007849294 |
| 1275 | 1625625 | 2072671875  | 35.7071421  | 10.8435144 | .0007843137 |
| 1276 | 1628176 | 2077552576  | 35.7211422  | 10.8463485 | .0007836991 |
| 1277 | 1630729 | 2082440933  | 35.7351367  | 10.8491812 | .0007830854 |
| 1278 | 1633284 | 2087336952  | 35.7491258  | 10.8520125 | .0007824726 |
| 1279 | 1635841 | 2092240639  | 35.7631095  | 10.8548422 | .0007818608 |
| 1280 | 1638400 | 2097152000  | 35.7770876  | 10.8576704 | .0007812500 |
| 1281 | 1640961 | 2102071041  | 35.7910603  | 10.8604972 | .0007806401 |
| 1282 | 1643524 | 2106997768  | 35.8050276  | 10.8633225 | .0007800312 |
| 1283 | 1646089 | 2111932187  | 35.8189894  | 10.8661464 | .0007794232 |
| 1284 | 1648656 | 2116874304  | 35.8329457  | 10.8689687 | .0007788162 |
| 1285 | 1651225 | 2121824125  | 35.8468966  | 10.8717897 | .0007782101 |
| 1286 | 1653796 | 2126781656  | 35.8608421  | 10.8746091 | .0007776050 |
| 1287 | 1656369 | 2131746903  | 35.8747822  | 10.8774271 | .0007770008 |
| 1288 | 1658944 | 2136719872  | 35.8887169  | 10.8802436 | .0007763975 |
| 1289 | 1661521 | 2141700569  | 35.9026461  | 10.8830587 | .0007757952 |
| 1290 | 1664100 | 2146689000  | 35.9165699  | 10.8858723 | .0007751938 |
| 1291 | 1666681 | 2151685171  | 35.9304884  | 10.8886845 | .0007745933 |
| 1292 | 1669264 | 2156689088  | 35.9444015  | 10.8914952 | .0007739938 |
| 1293 | 1671849 | 2161700757  | 35.9583092  | 10.8943044 | .0007733952 |
| 1294 | 1674436 | 2166720184  | 35.9722115  | 10.8971123 | .0007727975 |
| 1295 | 1677025 | 2171747375  | 35.9861084  | 10.8999186 | .0007722008 |
| 1296 | 1679616 | 2176782336  | 36.0000000  | 10.9027235 | .0007716049 |
| 1297 | 1682209 | 2181825073  | 36.0138862  | 10.9055269 | .0007710100 |
| 1298 | 1684804 | 2186875592  | 36.0277671  | 10.9083290 | .0007704160 |
| 1299 | 1687401 | 2191933899  | 36.0416426  | 10.9111296 | .0007698229 |
| 1300 | 1690000 | 2197000000  | 36.0555128  | 10.9139287 | .0007692308 |
| 1301 | 1692601 | 2202073901  | 36.0693776  | 10.9167265 | .0007686395 |
| 1302 | 1695204 | 2207155608  | 36.0832371  | 10.9195228 | .0007680492 |
| 1303 | 1697809 | 2212245127  | 36.0970913  | 10.9223177 | .0007674597 |
| 1304 | 1700416 | 2217342464  | 36.1109402  | 10.9251111 | .0007668712 |
| 1305 | 1703025 | 2222447625  | 36.1247887  | 10.9279031 | .0007662835 |
| 1306 | 1705636 | 2227560616  | 36.1386220  | 10.9306937 | .0007656968 |
| 1307 | 1708249 | 2232681443  | 36.1524550  | 10.9334829 | .0007651109 |
| 1308 | 1710864 | 2237810112  | 36.1662826  | 10.9362706 | .0007645260 |
| 1309 | 1713481 | 2242946629  | 36.1801050  | 10.9390569 | .0007639419 |
| 1310 | 1716100 | 2248091000  | 36.1939221  | 10.9418418 | .0007633588 |
| 1311 | 1718721 | 2253243231  | 36.2077340  | 10.9446253 | .0007627765 |
| 1312 | 1721344 | 2258403328  | 36.2215406  | 10.9474074 | .0007621951 |
| 1313 | 1723969 | 2263571297  | 36.2353419  | 10.9501880 | .0007616146 |
| 1314 | 1726596 | 2268747144  | 36.2491379  | 10.9529673 | .0007610350 |
| 1315 | 1729225 | 22739330875 | 36.2629287  | 10.9557451 | .0007604568 |
| 1316 | 1731856 | 2279122496  | 36.2767143  | 10.9585215 | .0007598784 |
| 1317 | 1734489 | 2284322013  | 36.2904946  | 10.9612965 | .0007593014 |
| 1318 | 1737124 | 2289529432  | 36.3042697  | 10.9640701 | .0007587253 |
| 1319 | 1739761 | 2294744759  | 36.3180396  | 10.9668423 | .0007581501 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1320 | 1742400 | 2299968000 | 86.3318042  | 10.9696131 | .0007575758 |
| 1321 | 1745041 | 2305199161 | 86.3455637  | 10.9723825 | .0007570023 |
| 1322 | 1747684 | 2310488248 | 86.3593179  | 10.9751505 | .0007564297 |
| 1323 | 1750329 | 2315685267 | 86.3730670  | 10.9779171 | .0007558579 |
| 1324 | 1752976 | 2320940224 | 86.3868108  | 10.9806823 | .0007552870 |
| 1325 | 1755625 | 2326208125 | 86.4005494  | 10.9834462 | .0007547170 |
| 1326 | 1758276 | 2331478976 | 86.4142829  | 10.9862086 | .0007541478 |
| 1327 | 1760929 | 2336752783 | 86.4280112  | 10.9889696 | .0007535795 |
| 1328 | 1763584 | 2342039552 | 86.4417343  | 10.9917293 | .0007530120 |
| 1329 | 1766241 | 2347334289 | 86.4554523  | 10.9944876 | .0007524454 |
| 1330 | 1768900 | 2352637000 | 86.4691650  | 10.9972445 | .0007518797 |
| 1331 | 1771561 | 2357947691 | 86.4828727  | 11.0000000 | .0007513148 |
| 1332 | 1774224 | 2363266368 | 86.4965752  | 11.0027541 | .0007507508 |
| 1333 | 1776889 | 2368593037 | 86.5102725  | 11.0055069 | .0007501875 |
| 1334 | 1779556 | 2373927704 | 86.5239647  | 11.0082583 | .0007496252 |
| 1335 | 1782225 | 2379270375 | 86.5376518  | 11.0110082 | .0007490637 |
| 1336 | 1784896 | 2384621056 | 86.5513338  | 11.0137569 | .0007485030 |
| 1337 | 1787569 | 2389979753 | 86.5650106  | 11.0165041 | .0007479432 |
| 1338 | 1790244 | 2395346472 | 86.5786823  | 11.0192500 | .0007473842 |
| 1339 | 1792921 | 2400721219 | 86.5923489  | 11.0220945 | .0007468260 |
| 1340 | 1795600 | 2406104000 | 86.6060104  | 11.0247377 | .0007462687 |
| 1341 | 1798281 | 2411494821 | 86.6196668  | 11.0274795 | .0007457122 |
| 1342 | 1800964 | 2416893688 | 86.6333181  | 11.0302199 | .0007451565 |
| 1343 | 1803649 | 2422300607 | 86.6469644  | 11.0329590 | .0007446016 |
| 1344 | 1806336 | 2427715584 | 86.6606056  | 11.0356967 | .0007440476 |
| 1345 | 1809025 | 2433138625 | 86.6742416  | 11.0384330 | .0007434944 |
| 1346 | 1811716 | 2438569736 | 86.6878726  | 11.0411680 | .0007429421 |
| 1347 | 1814409 | 2444008923 | 86.7014986  | 11.0439017 | .0007423905 |
| 1348 | 1817104 | 2449456192 | 86.7151195  | 11.0466339 | .0007418398 |
| 1349 | 1819801 | 2454911549 | 86.7287353  | 11.0493649 | .0007412898 |
| 1350 | 1822500 | 2460375000 | 86.7423461  | 11.0520945 | .0007407407 |
| 1351 | 1825201 | 2465846551 | 86.7559519  | 11.0548227 | .0007401924 |
| 1352 | 1827904 | 2471326208 | 86.7695526  | 11.0575497 | .0007396450 |
| 1353 | 1830609 | 2476813977 | 86.7831483  | 11.0602752 | .0007390988 |
| 1354 | 1833316 | 2482309864 | 86.7967390  | 11.0629994 | .0007385524 |
| 1355 | 1836025 | 2487813875 | 86.8103246  | 11.0657222 | .0007380074 |
| 1356 | 1838736 | 2493326016 | 86.8239053  | 11.0684437 | .0007374631 |
| 1357 | 1841449 | 2498846293 | 86.8374809  | 11.0711639 | .0007369197 |
| 1358 | 1844164 | 2504374712 | 86.8510515  | 11.0738828 | .0007363770 |
| 1359 | 1846881 | 2509911279 | 86.8646172  | 11.0766003 | .0007358352 |
| 1360 | 1849600 | 2515456000 | 86.8781778  | 11.0793165 | .0007352941 |
| 1361 | 1852321 | 2521008881 | 86.8917335  | 11.0820314 | .0007347539 |
| 1362 | 1855044 | 2526569928 | 86.9052842  | 11.0847449 | .0007342144 |
| 1363 | 1857769 | 2532139147 | 86.9188299  | 11.0874571 | .0007336757 |
| 1364 | 1860496 | 2537716544 | 86.9323706  | 11.0901679 | .0007331378 |
| 1365 | 1863225 | 2543302125 | 86.9459064  | 11.0928775 | .0007326007 |
| 1366 | 1865956 | 2548895896 | 86.9594372  | 11.0955857 | .0007320644 |
| 1367 | 1868689 | 2554497863 | 86.9729631  | 11.0982926 | .0007315289 |
| 1368 | 1871424 | 2560108032 | 86.9864840  | 11.1009982 | .0007309942 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1369 | 1874161 | 2565726409 | 87·0000000  | 11·1087025 | ·0007804602 |
| 1370 | 1876900 | 2571353000 | 87·0185110  | 11·1064054 | ·0007299270 |
| 1371 | 1879641 | 2576987811 | 87·0270172  | 11·1091070 | ·0007298946 |
| 1372 | 1882384 | 2582630848 | 87·0405184  | 11·1118073 | ·0007288650 |
| 1373 | 1885129 | 2588282117 | 87·0540146  | 11·1145064 | ·0007288321 |
| 1374 | 1887876 | 2593941624 | 87·0675060  | 11·1172041 | ·0007278020 |
| 1375 | 1890625 | 2599609375 | 87·0809924  | 11·1199004 | ·0007272727 |
| 1376 | 1893376 | 2605285376 | 87·0944740  | 11·1225955 | ·0007267442 |
| 1377 | 1896129 | 2610969633 | 87·1079506  | 11·1252893 | ·0007262164 |
| 1378 | 1898884 | 2616662152 | 87·1214224  | 11·1279817 | ·0007256894 |
| 1379 | 1901641 | 2622362939 | 87·1348893  | 11·1306729 | ·0007251682 |
| 1380 | 1904400 | 2628072000 | 87·1483512  | 11·1333628 | ·0007246377 |
| 1381 | 1907161 | 2633789341 | 87·1618084  | 11·1360514 | ·0007241180 |
| 1382 | 1909924 | 2639514968 | 87·1752606  | 11·1387386 | ·0007235890 |
| 1383 | 1912689 | 2645248887 | 87·1887079  | 11·1414246 | ·0007230658 |
| 1384 | 1915456 | 2650991104 | 87·2021505  | 11·1441093 | ·0007225484 |
| 1385 | 1918225 | 2656741625 | 87·2155881  | 11·1467926 | ·0007220217 |
| 1386 | 1920996 | 2662500456 | 87·2290209  | 11·1494747 | ·0007215007 |
| 1387 | 1923769 | 2668267603 | 87·2424489  | 11·1521555 | ·0007209806 |
| 1388 | 1926544 | 2674043072 | 87·2558720  | 11·1548350 | ·0007204611 |
| 1389 | 1929321 | 2679826869 | 87·2692903  | 11·1575133 | ·0007199424 |
| 1390 | 1932100 | 2685619000 | 87·2827037  | 11·1601908 | ·0007194245 |
| 1391 | 1934881 | 2691419471 | 87·2961124  | 11·1628659 | ·0007189078 |
| 1392 | 1937664 | 2697228288 | 87·3095162  | 11·1655403 | ·0007183908 |
| 1393 | 1940449 | 2703045457 | 87·3229152  | 11·1682134 | ·0007178751 |
| 1394 | 1943236 | 2708870984 | 87·3363094  | 11·1708852 | ·0007173601 |
| 1395 | 1946025 | 2714704875 | 87·3496988  | 11·1735558 | ·0007168459 |
| 1396 | 1948816 | 2720547136 | 87·3630884  | 11·1762250 | ·0007163324 |
| 1397 | 1951609 | 2726397773 | 87·3764632  | 11·1788930 | ·0007158196 |
| 1398 | 1954404 | 2732256792 | 87·3898382  | 11·1815598 | ·0007153076 |
| 1399 | 1957201 | 2738124199 | 87·4032084  | 11·1842252 | ·0007147968 |
| 1400 | 1960000 | 2744000000 | 87·4165738  | 11·1868894 | ·0007142857 |
| 1401 | 1962801 | 2749884201 | 87·4299345  | 11·1895523 | ·0007137759 |
| 1402 | 1965604 | 2755776808 | 87·4432904  | 11·1922139 | ·0007132668 |
| 1403 | 1968409 | 2761677827 | 87·4566416  | 11·1948743 | ·0007127584 |
| 1404 | 1971216 | 2767587264 | 87·4699880  | 11·1975334 | 0007122507  |
| 1405 | 1974025 | 2773505125 | 87·4833296  | 11·2001913 | ·0007117488 |
| 1406 | 1976836 | 2779431416 | 87·4966665  | 11·2028479 | ·0007112376 |
| 1407 | 1979649 | 2785366143 | 87·5099987  | 11·2055032 | ·0007107321 |
| 1408 | 1982464 | 2791309312 | 87·5233261  | 11·2081573 | ·0007102273 |
| 1409 | 1985281 | 2797260929 | 87·5366487  | 11·2108101 | ·0007097232 |
| 1410 | 1988100 | 2803221000 | 87·5499667  | 11·2134617 | ·0007092199 |
| 1411 | 1990921 | 2809189531 | 87·5632799  | 11·2161120 | ·0007087172 |
| 1412 | 1993744 | 2815166528 | 87·5765885  | 11·2187611 | ·0007082158 |
| 1413 | 1996569 | 2821151997 | 87·5898922  | 11·2214089 | ·0007077141 |
| 1414 | 1999396 | 2827145944 | 87·6031913  | 11·2240554 | ·0007072136 |
| 1415 | 2002225 | 2833148375 | 87·6164857  | 11·2267007 | ·0007067138 |
| 1416 | 2005056 | 2839159296 | 87·6297754  | 11·2293448 | ·0007062147 |
| 1417 | 2007889 | 2845178713 | 87·6430604  | 11·2319876 | ·0007057168 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1418 | 2010724 | 2851206682 | 37·6568407  | 11·2346292 | ·0007052186 |
| 1419 | 2018561 | 2857248059 | 37·6696164  | 11·2372696 | ·0007047216 |
| 1420 | 2016400 | 2863288000 | 37·6828874  | 11·2399087 | ·0007042254 |
| 1421 | 2019241 | 2869341461 | 37·6961586  | 11·2425465 | ·0007037298 |
| 1422 | 2022084 | 2875403448 | 37·7094113  | 11·2451881 | ·0007032349 |
| 1423 | 2024929 | 2881473967 | 37·7226722  | 11·2478185 | ·0007027407 |
| 1424 | 2027776 | 2887553024 | 37·7359245  | 11·2504527 | ·0007022472 |
| 1425 | 2030625 | 2893640625 | 37·7491722  | 11·2530856 | ·0007017544 |
| 1426 | 2033476 | 2899736776 | 37·7624152  | 11·2557173 | ·0007012623 |
| 1427 | 2036329 | 2905841483 | 37·7756585  | 11·2583478 | ·0007007708 |
| 1428 | 2039184 | 2911954752 | 37·7888873  | 11·2609770 | ·0007002801 |
| 1429 | 2042041 | 2918076589 | 37·8021163  | 11·2636050 | ·0006997901 |
| 1430 | 2044900 | 2924207000 | 37·8153408  | 11·2662318 | ·0006993007 |
| 1431 | 2047761 | 2930345991 | 37·8285606  | 11·2688573 | ·0006988120 |
| 1432 | 2050624 | 2936493568 | 37·8417759  | 11·2714816 | ·0006983240 |
| 1433 | 2053489 | 2942649737 | 37·8549864  | 11·2741047 | ·0006978367 |
| 1434 | 2056356 | 2948814504 | 37·8681924  | 11·2767266 | ·0006973501 |
| 1435 | 2059225 | 2954987875 | 37·8813988  | 11·2793472 | ·0006968641 |
| 1436 | 2062096 | 2961169856 | 37·8945906  | 11·2819666 | ·0006963788 |
| 1437 | 2064969 | 2967360453 | 37·9077828  | 11·2845849 | ·0006958942 |
| 1438 | 2067844 | 2973559672 | 37·9209704  | 11·2872019 | ·0006954103 |
| 1439 | 2070721 | 2979767519 | 37·9341585  | 11·2898177 | ·0006949270 |
| 1440 | 2073600 | 2985984000 | 37·9473319  | 11·2924323 | ·0006944444 |
| 1441 | 2076481 | 2992209121 | 37·9605058  | 11·2950457 | ·0006939625 |
| 1442 | 2079364 | 2998442888 | 37·9736751  | 11·2976579 | ·0006934813 |
| 1443 | 2082249 | 3004685307 | 37·9868398  | 11·3002688 | ·0006930007 |
| 1444 | 2085136 | 3010936384 | 38·0000000  | 11·3028786 | ·0006925208 |
| 1445 | 2088025 | 3017196125 | 38·0131556  | 11·3054871 | ·0006920415 |
| 1446 | 2090916 | 3023464536 | 38·0263067  | 11·3080945 | ·0006915629 |
| 1447 | 2093809 | 3029741623 | 38·0394532  | 11·3107006 | ·0006910850 |
| 1448 | 2096704 | 3036027392 | 38·0525952  | 11·3133056 | ·0006906078 |
| 1449 | 2099601 | 3042321849 | 38·0657326  | 11·3159094 | ·0006901312 |
| 1450 | 2102500 | 3048625000 | 38·0788655  | 11·3185119 | ·0006896552 |
| 1451 | 2105401 | 3054936851 | 38·0919939  | 11·3211132 | ·0006891799 |
| 1452 | 2108304 | 3061257408 | 38·1051178  | 11·3237134 | ·0006887052 |
| 1453 | 2111209 | 3067586677 | 38·1182371  | 11·3263124 | ·0006882312 |
| 1454 | 2114116 | 3073924664 | 38·1313519  | 11·3289102 | ·0006877579 |
| 1455 | 2117025 | 3080271375 | 38·1444622  | 11·3315067 | ·0006872852 |
| 1456 | 2119936 | 3086626816 | 38·1575681  | 11·3341022 | ·0006868132 |
| 1457 | 2122849 | 3092990993 | 38·1706693  | 11·3366964 | ·0006863418 |
| 1458 | 2125764 | 3099363912 | 38·1837662  | 11·3392894 | ·0006858711 |
| 1459 | 2128681 | 3105745579 | 38·1968585  | 11·3418813 | ·0006854010 |
| 1460 | 2131600 | 3112136000 | 38·2099463  | 11·3444719 | ·0006849315 |
| 1461 | 2134521 | 3118535181 | 38·2230297  | 11·3470614 | ·0006844627 |
| 1462 | 2137444 | 3124943128 | 38·2361085  | 11·3496497 | ·0006839945 |
| 1463 | 2140369 | 3131359847 | 38·2491829  | 11·3522368 | ·0006835270 |
| 1464 | 2143296 | 3137785344 | 38·2622529  | 11·3548227 | ·0006830601 |
| 1465 | 2146225 | 3144219625 | 38·2753184  | 11·3574075 | ·0006825989 |
| 1466 | 2149156 | 3150662696 | 38·2883794  | 11·3599911 | ·0006821282 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1369 | 1874161 | 2565726409 | 37.0000000  | 11.1037025 | .0007304602 |
| 1370 | 1876900 | 2571353000 | 37.0135110  | 11.1064054 | .0007299270 |
| 1371 | 1879641 | 2576987811 | 37.0270172  | 11.1091070 | .0007293946 |
| 1372 | 1882384 | 2582630848 | 37.0405184  | 11.1118073 | .0007288630 |
| 1373 | 1885129 | 2588282117 | 37.0540146  | 11.1145064 | .0007283321 |
| 1374 | 1887876 | 2593941624 | 37.0675060  | 11.1172041 | .0007278020 |
| 1375 | 1890625 | 2599609375 | 37.0809924  | 11.1199004 | .0007272727 |
| 1376 | 1893376 | 2605285376 | 37.0944740  | 11.1225955 | .0007267442 |
| 1377 | 1896129 | 2610969633 | 37.1079506  | 11.1252893 | .0007262164 |
| 1378 | 1898884 | 2616662152 | 37.1214224  | 11.1279817 | .0007256894 |
| 1379 | 1901641 | 2622362939 | 37.1348893  | 11.1306729 | .0007251632 |
| 1380 | 1904400 | 2628072000 | 37.1483512  | 11.1333628 | .0007246377 |
| 1381 | 1907161 | 2633789341 | 37.1618084  | 11.1360514 | .0007241180 |
| 1382 | 1909924 | 2639514968 | 37.1752606  | 11.1387386 | .0007235890 |
| 1383 | 1912689 | 2645248887 | 37.1887079  | 11.1414246 | .0007230658 |
| 1384 | 1915456 | 2650991104 | 37.2021505  | 11.1441093 | .0007225484 |
| 1385 | 1918225 | 2656741625 | 37.2155881  | 11.1467926 | .0007220217 |
| 1386 | 1920996 | 2662500456 | 37.2290209  | 11.1494747 | .0007215007 |
| 1387 | 1923769 | 2668267603 | 37.2424489  | 11.1521555 | .0007209805 |
| 1388 | 1926544 | 2674043072 | 37.2558720  | 11.1548350 | .0007204611 |
| 1389 | 1929321 | 2679826869 | 37.2692903  | 11.1575133 | .0007199424 |
| 1390 | 1932100 | 2685619000 | 37.2827037  | 11.1601903 | .0007194245 |
| 1391 | 1934881 | 2691419471 | 37.2961124  | 11.1628659 | .0007189078 |
| 1392 | 1937664 | 2697228288 | 37.3095162  | 11.1655403 | .0007183908 |
| 1393 | 1940449 | 2703045457 | 37.3229152  | 11.1682134 | .0007178751 |
| 1394 | 1943236 | 2708870984 | 37.3363094  | 11.1708852 | .0007173601 |
| 1395 | 1946025 | 2714704875 | 37.3496988  | 11.1735558 | .0007168459 |
| 1396 | 1948816 | 2720547136 | 37.3630834  | 11.1762250 | .0007163324 |
| 1397 | 1951609 | 2726397773 | 37.3764632  | 11.1788930 | .0007158196 |
| 1398 | 1954404 | 2732256792 | 37.3898382  | 11.1815598 | .0007153076 |
| 1399 | 1957201 | 2738124199 | 37.4032084  | 11.1842252 | .0007147963 |
| 1400 | 1960000 | 2744000000 | 37.4165738  | 11.1868894 | .0007142857 |
| 1401 | 1962801 | 2749884201 | 37.4299345  | 11.1895523 | .0007137759 |
| 1402 | 1965604 | 2755776808 | 37.4432904  | 11.1922139 | .0007132668 |
| 1403 | 1968409 | 2761677827 | 37.4566416  | 11.1948743 | .0007127584 |
| 1404 | 1971216 | 2767587264 | 37.4699880  | 11.1975334 | .0007122507 |
| 1405 | 1974025 | 2773505125 | 37.4833296  | 11.2001913 | .0007117438 |
| 1406 | 1976836 | 2779431416 | 37.4966665  | 11.2028479 | .0007112376 |
| 1407 | 1979649 | 2785366143 | 37.5099987  | 11.2055032 | .0007107321 |
| 1408 | 1982464 | 2791309312 | 37.5233261  | 11.2081573 | .0007102273 |
| 1409 | 1985281 | 2797260929 | 37.5366487  | 11.2108101 | .0007097232 |
| 1410 | 1988100 | 2803221000 | 37.5499667  | 11.2134617 | .0007092199 |
| 1411 | 1990921 | 2809189531 | 37.5632799  | 11.2161120 | .0007087172 |
| 1412 | 1993744 | 2815166528 | 37.5765885  | 11.2187611 | .0007082158 |
| 1413 | 1996569 | 2821151997 | 37.5898922  | 11.2214089 | .0007077141 |
| 1414 | 1999396 | 2827145944 | 37.6031913  | 11.2240554 | .0007072136 |
| 1415 | 2002225 | 2833148375 | 37.6164857  | 11.2267007 | .0007067138 |
| 1416 | 2005056 | 2839159296 | 37.6297754  | 11.2293448 | .0007062147 |
| 1417 | 2007889 | 2845178713 | 37.6430604  | 11.2319876 | .0007057163 |



| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1418 | 2010724 | 2851206682 | 87.6563407  | 11.2346292 | .0007052186 |
| 1419 | 2018561 | 2857243059 | 87.6696164  | 11.2372696 | .0007047216 |
| 1420 | 2016400 | 2863288000 | 87.6828874  | 11.2399087 | .0007042254 |
| 1421 | 2019241 | 2869341461 | 87.6961536  | 11.2425465 | .0007037298 |
| 1422 | 2022084 | 2875403448 | 87.7094113  | 11.2451831 | .0007032349 |
| 1423 | 2024929 | 2881473967 | 87.7226722  | 11.2478185 | .0007027407 |
| 1424 | 2027776 | 2887553024 | 87.7359245  | 11.2504527 | .0007022472 |
| 1425 | 2030625 | 2893640625 | 87.7491722  | 11.2530856 | .0007017544 |
| 1426 | 2033476 | 2899736776 | 87.7624152  | 11.2557173 | .0007012623 |
| 1427 | 2036329 | 2905841483 | 87.7756535  | 11.2583478 | .0007007708 |
| 1428 | 2039184 | 2911954752 | 87.7888873  | 11.2609770 | .0007002801 |
| 1429 | 2042041 | 2918076589 | 87.8021163  | 11.2636050 | .0006997901 |
| 1430 | 2044900 | 2924207000 | 87.8153408  | 11.2662318 | .0006993007 |
| 1431 | 2047761 | 2930345991 | 87.8285606  | 11.2688573 | .0006988120 |
| 1432 | 2050624 | 2936493568 | 87.8417759  | 11.2714816 | .0006983240 |
| 1433 | 2053489 | 2942649737 | 87.8549864  | 11.2741047 | .0006978367 |
| 1434 | 2056356 | 2948814504 | 87.8681924  | 11.2767266 | .0006973501 |
| 1435 | 2059225 | 2954987875 | 87.8813988  | 11.2793472 | .0006968641 |
| 1436 | 2062096 | 2961169856 | 87.8945906  | 11.2819666 | .0006963788 |
| 1437 | 2064969 | 2967360453 | 87.9077828  | 11.2845849 | .0006958942 |
| 1438 | 2067844 | 2973559672 | 87.9209704  | 11.2872019 | .0006954103 |
| 1439 | 2070721 | 2979767519 | 87.9341535  | 11.2898177 | .0006949270 |
| 1440 | 2073600 | 2985984000 | 87.9473319  | 11.2924323 | .0006944444 |
| 1441 | 2076481 | 2992209121 | 87.9605058  | 11.2950457 | .0006939625 |
| 1442 | 2079364 | 2998442888 | 87.9736751  | 11.2976579 | .0006934813 |
| 1443 | 2082249 | 3004685307 | 87.9868398  | 11.3002688 | .0006930007 |
| 1444 | 2085136 | 3010936384 | 88.0000000  | 11.3028786 | .0006925208 |
| 1445 | 2088025 | 3017196125 | 88.0131556  | 11.3054871 | .0006920415 |
| 1446 | 2090916 | 3023464536 | 88.0263067  | 11.3080945 | .0006915629 |
| 1447 | 2093809 | 3029741623 | 88.0394532  | 11.3107006 | .0006910850 |
| 1448 | 2096704 | 3036027392 | 88.0525952  | 11.3133056 | .0006906078 |
| 1449 | 2099601 | 3042321849 | 88.0657326  | 11.3159094 | .0006901312 |
| 1450 | 2102500 | 3048625000 | 88.0788655  | 11.3185119 | .0006896552 |
| 1451 | 2105401 | 3054936851 | 88.0919939  | 11.3211132 | .0006891799 |
| 1452 | 2108304 | 3061257408 | 88.1051178  | 11.3237134 | .0006887052 |
| 1453 | 2111209 | 3067586677 | 88.1182371  | 11.3263124 | .0006882312 |
| 1454 | 2114116 | 3073924664 | 88.1313519  | 11.3289102 | .0006877579 |
| 1455 | 2117025 | 3080271375 | 88.1444622  | 11.3315067 | .0006872852 |
| 1456 | 2119936 | 3086626816 | 88.1575681  | 11.3341022 | .0006868132 |
| 1457 | 2122849 | 3092990993 | 88.1706693  | 11.3366964 | .0006863418 |
| 1458 | 2125764 | 3099363912 | 88.1837662  | 11.3392894 | .0006858711 |
| 1459 | 2128681 | 3105745579 | 88.1968585  | 11.3418813 | .0006854010 |
| 1460 | 2131600 | 3112136000 | 88.2099463  | 11.3444719 | .0006849315 |
| 1461 | 2134521 | 3118535181 | 88.2230297  | 11.3470614 | .0006844627 |
| 1462 | 2137444 | 3124943128 | 88.2361085  | 11.3496497 | .0006839945 |
| 1463 | 2140369 | 3131359847 | 88.2491829  | 11.3522368 | .0006835270 |
| 1464 | 2143296 | 3137785344 | 88.2622529  | 11.3548227 | .0006830601 |
| 1465 | 2146225 | 3144219625 | 88.2753184  | 11.3574075 | .0006825939 |
| 1466 | 2149156 | 3150662696 | 88.2883794  | 11.3599911 | .0006821282 |



| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1467 | 2152089 | 8157114563 | 38.3014360  | 11.3625735 | .0006816683 |
| 1468 | 2155024 | 8163575282 | 38.3144881  | 11.3651547 | .0006811989 |
| 1469 | 2157961 | 8170044709 | 38.3275358  | 11.3677347 | .0006807352 |
| 1470 | 2160900 | 8176523000 | 38.3405790  | 11.3703136 | .0006802721 |
| 1471 | 2163841 | 8183010111 | 38.3536178  | 11.3728914 | .0006798097 |
| 1472 | 2166784 | 8189506048 | 38.3666522  | 11.3754679 | .0006793478 |
| 1473 | 2169729 | 8196010817 | 38.3796821  | 11.3780433 | .0006788866 |
| 1474 | 2172676 | 8202524424 | 38.3927076  | 11.3806175 | .0006784261 |
| 1475 | 2175625 | 8209046875 | 38.4057287  | 11.3831906 | .0006779661 |
| 1476 | 2178576 | 8215578176 | 38.4187454  | 11.3857625 | .0006775068 |
| 1477 | 2181529 | 8222118383 | 38.4317577  | 11.3883382 | .0006770481 |
| 1478 | 2184484 | 8228667852 | 38.4447656  | 11.3909028 | .0006765900 |
| 1479 | 2187441 | 8235225239 | 38.4577691  | 11.3934712 | .0006761325 |
| 1480 | 2190400 | 8241792000 | 38.4707681  | 11.3960384 | .0006756757 |
| 1481 | 2193361 | 8248367641 | 38.4837627  | 11.3986045 | .0006752194 |
| 1482 | 2196324 | 8254952168 | 38.4967580  | 11.4011695 | .0006747688 |
| 1483 | 2199289 | 8261545587 | 38.5097390  | 11.4037382 | .0006743088 |
| 1484 | 2202256 | 8268147904 | 38.5227206  | 11.4062959 | .0006738544 |
| 1485 | 2205225 | 8274759125 | 38.5356977  | 11.4088574 | .0006734007 |
| 1486 | 2208196 | 8281379256 | 38.5486705  | 11.4114177 | .0006729475 |
| 1487 | 2211169 | 8288008303 | 38.5616389  | 11.4139769 | .0006724950 |
| 1488 | 2214144 | 8294646272 | 38.5746030  | 11.4165349 | .0006720430 |
| 1489 | 2217121 | 8301293169 | 38.5875627  | 11.4190918 | .0006715917 |
| 1490 | 2220100 | 8307949000 | 38.6005181  | 11.4216476 | .0006711409 |
| 1491 | 2223081 | 8314618771 | 38.6134691  | 11.4242022 | .0006706908 |
| 1492 | 2226064 | 8321287488 | 38.6264158  | 11.4267556 | .0006702418 |
| 1493 | 2229049 | 8327970157 | 38.6393582  | 11.4293079 | .0006697924 |
| 1494 | 2232036 | 8334661784 | 38.6522962  | 11.4318591 | .0006693440 |
| 1495 | 2235025 | 8341362375 | 38.6652299  | 11.4344092 | .0006688968 |
| 1496 | 2238016 | 8348071936 | 38.6781593  | 11.4369581 | .0006684492 |
| 1497 | 2241009 | 8354790473 | 38.6910843  | 11.4395059 | .0006680027 |
| 1498 | 2244004 | 8361517992 | 38.7040050  | 11.4420525 | .0006675567 |
| 1499 | 2247001 | 8368254499 | 38.7169214  | 11.4445980 | .0006671114 |
| 1500 | 2250000 | 8375000000 | 38.7298335  | 11.4471424 | .0006666667 |
| 1501 | 2253001 | 8381754501 | 38.7427412  | 11.4496857 | .0006662225 |
| 1502 | 2256004 | 8388518008 | 38.7556447  | 11.4522278 | .0006657790 |
| 1503 | 2259009 | 8395290527 | 38.7685439  | 11.4547688 | .0006653360 |
| 1504 | 2262016 | 8402072064 | 38.7814389  | 11.4573087 | .0006648936 |
| 1505 | 2265025 | 8408862625 | 38.7943294  | 11.4598474 | .0006644518 |
| 1506 | 2268036 | 8415662216 | 38.8072158  | 11.4623850 | .0006640106 |
| 1507 | 2271049 | 8422470843 | 38.8200978  | 11.4649215 | .0006635700 |
| 1508 | 2274064 | 8429288512 | 38.8329757  | 11.4674568 | .0006631300 |
| 1509 | 2277081 | 8436115229 | 38.8458491  | 11.4699911 | .0006626905 |
| 1510 | 2280100 | 8442951000 | 38.8587184  | 11.4725242 | .0006622517 |
| 1511 | 2283121 | 8449795831 | 38.8715834  | 11.4750562 | .0006618134 |
| 1512 | 2286144 | 8456649728 | 38.8844442  | 11.4775871 | .0006613757 |
| 1513 | 2289169 | 8463512697 | 38.8973006  | 11.4801169 | .0006609385 |
| 1514 | 2292196 | 8470384744 | 38.9101529  | 11.4826455 | .0006605020 |
| 1515 | 2295225 | 8477265875 | 38.9230009  | 11.4851731 | .0006600660 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1516 | 2298256 | 3484156096 | 38.9358447  | 11.4876995 | .0006596306 |
| 1517 | 2301289 | 3491055413 | 38.9486841  | 11.4902249 | .0006591958 |
| 1518 | 2304324 | 3497963832 | 38.9615194  | 11.4927491 | .0006587615 |
| 1519 | 2307361 | 3504881359 | 38.9743505  | 11.4952722 | .0006583278 |
| 1520 | 2310400 | 3511808000 | 38.9871774  | 11.4977942 | .0006578947 |
| 1521 | 2313441 | 3518743761 | 39.0000000  | 11.5003151 | .0006574622 |
| 1522 | 2316484 | 3525688648 | 39.0128184  | 11.5028348 | .0006570302 |
| 1523 | 2319529 | 3532642667 | 39.0256326  | 11.5053535 | .0006565988 |
| 1524 | 2322576 | 3539605824 | 39.0384426  | 11.5078711 | .0006561680 |
| 1525 | 2325625 | 3546578125 | 39.0512483  | 11.5103876 | .0006557377 |
| 1526 | 2328676 | 3553559576 | 39.0640499  | 11.5129030 | .0006553080 |
| 1527 | 2331729 | 3560550183 | 39.0768473  | 11.5154173 | .0006548788 |
| 1528 | 2334784 | 3567549952 | 39.0896406  | 11.5179305 | .0006544503 |
| 1529 | 2337841 | 3574558889 | 39.1024296  | 11.5204425 | .0006540222 |
| 1530 | 2340900 | 3581577000 | 39.1152144  | 11.5229535 | .0006535948 |
| 1531 | 2343961 | 3588604291 | 39.1279951  | 11.5254634 | .0006531679 |
| 1532 | 2347024 | 3595640768 | 39.1407716  | 11.5279722 | .0006527415 |
| 1533 | 2350089 | 3602686437 | 39.1535430  | 11.5304799 | .0006523157 |
| 1534 | 2353156 | 3609741304 | 39.1663120  | 11.5329865 | .0006518905 |
| 1535 | 2356225 | 3616805375 | 39.1790760  | 11.5354920 | .0006514658 |
| 1536 | 2359296 | 3623878656 | 39.1918359  | 11.5379965 | .0006510417 |
| 1537 | 2362369 | 3630961153 | 39.2045915  | 11.5404998 | .0006506181 |
| 1538 | 2365444 | 3638052872 | 39.2173431  | 11.5430021 | .0006501951 |
| 1539 | 2368521 | 3645153819 | 39.2300905  | 11.5455033 | .0006497726 |
| 1540 | 2371600 | 3652264000 | 39.2428337  | 11.5480034 | .0006493506 |
| 1541 | 2374681 | 3659383421 | 39.2555728  | 11.5505025 | .0006489293 |
| 1542 | 2377764 | 3666512088 | 39.2683078  | 11.5530004 | .0006485081 |
| 1543 | 2380849 | 3673650007 | 39.2810387  | 11.5554973 | .0006480881 |
| 1544 | 2383936 | 3680797184 | 39.2937654  | 11.5579931 | .0006476684 |
| 1545 | 2387025 | 3687953625 | 39.3064880  | 11.5604878 | .0006472492 |
| 1546 | 2390116 | 3695119336 | 39.3192065  | 11.5629815 | .0006468305 |
| 1547 | 2393209 | 3702294323 | 39.3319208  | 11.5654740 | .0006464124 |
| 1548 | 2396304 | 3709478592 | 39.3446311  | 11.5679655 | .0006459948 |
| 1549 | 2399401 | 3716672149 | 39.3573373  | 11.5704559 | .0006455778 |
| 1550 | 2402500 | 3723875000 | 39.3700394  | 11.5729453 | .0006451613 |
| 1551 | 2405601 | 3731087151 | 39.3827373  | 11.5754336 | .0006447453 |
| 1552 | 2408704 | 3738308608 | 39.3954312  | 11.5779208 | .0006443299 |
| 1553 | 2411809 | 3745539377 | 39.4081210  | 11.5804069 | .0006439150 |
| 1554 | 2414916 | 3752779464 | 39.4208067  | 11.5828919 | .0006435006 |
| 1555 | 2418025 | 3760028875 | 39.4334883  | 11.5853759 | .0006430868 |
| 1556 | 2421136 | 3767287616 | 39.4461658  | 11.5878588 | .0006426735 |
| 1557 | 2424249 | 3774555693 | 39.4588393  | 11.5903407 | .0006422608 |
| 1558 | 2427364 | 3781833112 | 39.4715087  | 11.5928215 | .0006418485 |
| 1559 | 2430481 | 3789119879 | 39.4841740  | 11.5953013 | .0006414368 |
| 1560 | 2433600 | 3796416000 | 39.4968353  | 11.5977799 | .0006410256 |
| 1561 | 2436721 | 3803721481 | 39.5094925  | 11.6002576 | .0006406150 |
| 1562 | 2439844 | 3811036328 | 39.5221457  | 11.6027342 | .0006402049 |
| 1563 | 2442969 | 3818360547 | 39.5347948  | 11.6052097 | .0006397953 |
| 1564 | 2446096 | 3825694144 | 39.5474399  | 11.6076841 | .0006393862 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1565 | 2449225 | 3833037125 | 39.5600809  | 11.6101575 | .0006889776 |
| 1566 | 2452356 | 3840389496 | 39.5727179  | 11.6126299 | .0006885696 |
| 1567 | 2455489 | 3847751263 | 39.5853508  | 11.6151012 | .0006881621 |
| 1568 | 2458624 | 3855122432 | 39.5979797  | 11.6175715 | .0006877551 |
| 1569 | 2461761 | 3862503009 | 39.6106046  | 11.6200407 | .0006873486 |
| 1570 | 2464900 | 3869893000 | 39.6232255  | 11.6225088 | .0006869427 |
| 1571 | 2468041 | 3877292411 | 39.6358424  | 11.6249759 | .0006865372 |
| 1572 | 2471184 | 3884701248 | 39.6484552  | 11.6274420 | .0006861328 |
| 1573 | 2474329 | 3892119517 | 39.6610640  | 11.6299070 | .0006857279 |
| 1574 | 2477476 | 3899547224 | 39.6736688  | 11.6323710 | .0006853240 |
| 1575 | 2480625 | 3906984375 | 39.6862696  | 11.6348339 | .0006849206 |
| 1576 | 2483776 | 3914430976 | 39.6988665  | 11.6372957 | .0006845178 |
| 1577 | 2486929 | 3921887033 | 39.7114593  | 11.6397566 | .0006841154 |
| 1578 | 2490084 | 3929352552 | 39.7240481  | 11.6422164 | .0006837186 |
| 1579 | 2493241 | 3936827539 | 39.7366329  | 11.6446751 | .0006833122 |
| 1580 | 2496400 | 3944312000 | 39.7492138  | 11.6471329 | .0006829114 |
| 1581 | 2499561 | 3951805941 | 39.7617907  | 11.6495895 | .0006825111 |
| 1582 | 2502724 | 3959309368 | 39.7743636  | 11.6520452 | .0006821113 |
| 1583 | 2505889 | 3966822287 | 39.7869325  | 11.6544998 | .0006817119 |
| 1584 | 2509056 | 3974344704 | 39.7994975  | 11.6569534 | .0006813181 |
| 1585 | 2512225 | 3981876625 | 39.8120585  | 11.6594059 | .0006809148 |
| 1586 | 2515396 | 3989418056 | 39.8246155  | 11.6618574 | .0006805170 |
| 1587 | 2518569 | 3996969003 | 39.8371686  | 11.6643079 | .0006801197 |
| 1588 | 2521744 | 4004529472 | 39.8497177  | 11.6667574 | .0006797229 |
| 1589 | 2524921 | 4012099469 | 39.8622628  | 11.6692058 | .0006793266 |
| 1590 | 2528100 | 4019679000 | 39.8748040  | 11.6716532 | .0006789308 |
| 1591 | 2531281 | 4027268071 | 39.8873413  | 11.6740996 | .0006785355 |
| 1592 | 2534464 | 4034866688 | 39.8998747  | 11.6765449 | .0006781407 |
| 1593 | 2537649 | 4042474857 | 39.9124041  | 11.6789892 | .0006777464 |
| 1594 | 2540836 | 4050092584 | 39.9249295  | 11.6814325 | .0006773526 |
| 1595 | 2544025 | 4057719875 | 39.9374511  | 11.6838748 | .0006769592 |
| 1596 | 2547216 | 4065356736 | 39.9499687  | 11.6863161 | .0006765664 |
| 1597 | 2550409 | 4073003173 | 39.9624824  | 11.6887563 | .0006761741 |
| 1598 | 2553604 | 4080659192 | 39.9749922  | 11.6911955 | .0006757822 |
| 1599 | 2556801 | 4088324799 | 39.9874980  | 11.6936337 | .0006753909 |
| 1600 | 2560000 | 4096000000 | 40.0000000  | 11.6960709 | .0006750000 |
| 1601 | 2563201 | 4103684801 | 40.0124980  | 11.6985071 | .0006746096 |
| 1602 | 2566404 | 4111379208 | 40.0249922  | 11.7009422 | .0006742197 |
| 1603 | 2569609 | 4119083227 | 40.0374824  | 11.7033764 | .0006738303 |
| 1604 | 2572816 | 4126796864 | 40.0499688  | 11.7058095 | .0006734414 |
| 1605 | 2576025 | 4134520125 | 40.0624512  | 11.7082417 | .0006730530 |
| 1606 | 2579236 | 4142253016 | 40.0749298  | 11.7106728 | .0006726650 |
| 1607 | 2582449 | 4149995543 | 40.0874045  | 11.7131029 | .0006722775 |
| 1608 | 2585664 | 4157747712 | 40.0998753  | 11.7155320 | .0006718905 |
| 1609 | 2588881 | 4165509529 | 40.1123423  | 11.7179601 | .0006715040 |
| 1610 | 2592100 | 4173281000 | 40.1248053  | 11.7203872 | .0006711180 |
| 1611 | 2595321 | 4181062131 | 40.1372645  | 11.7228133 | .0006707325 |
| 1612 | 2598544 | 4188852928 | 40.1497198  | 11.7252384 | .0006703474 |
| 1613 | 2601769 | 4196658397 | 40.1621713  | 11.7276625 | .0006699628 |

|         | Square     | Cube       | Square Root | Cube Root   | Reciprocal |
|---------|------------|------------|-------------|-------------|------------|
| 2604996 | 4204468544 | 40.1746188 | 11.7300855  | .0006195787 |            |
| 2606225 | 4212288375 | 40.1870626 | 11.7325076  | .0006191950 |            |
| 2611456 | 4220112896 | 40.1995025 | 11.7349286  | .0006188119 |            |
| 2614689 | 4227952113 | 40.2119385 | 11.7373487  | .0006184292 |            |
| 2617924 | 4235801032 | 40.2248707 | 11.7397677  | .0006180470 |            |
| 2621161 | 4243659659 | 40.2367990 | 11.7421858  | .0006176652 |            |
| 2624400 | 4251528000 | 40.2492236 | 11.7446029  | .0006172840 |            |
| 2627641 | 4259406061 | 40.2616448 | 11.7470190  | .0006169031 |            |
| 2630884 | 4267293848 | 40.2740611 | 11.7494341  | .0006165228 |            |
| 2634129 | 4275191367 | 40.2864742 | 11.7518482  | .0006161429 |            |
| 2637376 | 4283098624 | 40.2988834 | 11.7542613  | .0006157635 |            |
| 2640625 | 4291015625 | 40.3112888 | 11.7566734  | .0006153846 |            |
| 2643876 | 4298942376 | 40.3236903 | 11.7590846  | .0006150062 |            |
| 2647129 | 4306878883 | 40.3360881 | 11.7614947  | .0006146282 |            |
| 2650384 | 4314825152 | 40.3484820 | 11.7639039  | .0006142506 |            |
| 2653641 | 4322781189 | 40.3608721 | 11.7663121  | .0006138735 |            |
| 2656900 | 4330747000 | 40.3732585 | 11.7687193  | .0006134969 |            |
| 2660161 | 4338722591 | 40.3856410 | 11.7711255  | .0006131208 |            |
| 2663424 | 4346707968 | 40.3980198 | 11.7735306  | .0006127451 |            |
| 2666689 | 4354703137 | 40.4103947 | 11.7759349  | .0006123699 |            |
| 2669956 | 4362708104 | 40.4227658 | 11.7783381  | .0006119951 |            |
| 2673225 | 4370722875 | 40.4351382 | 11.7807404  | .0006116208 |            |
| 2676496 | 4378747456 | 40.4474968 | 11.7831417  | .0006112469 |            |
| 2679769 | 4386781853 | 40.4598566 | 11.7855420  | .0006108785 |            |
| 2683044 | 4394826072 | 40.4722127 | 11.7879414  | .0006105006 |            |
| 2686321 | 4402880119 | 40.4845649 | 11.7903397  | .0006101281 |            |
| 2689600 | 4410944000 | 40.4969185 | 11.7927371  | .0006097561 |            |
| 2692881 | 4419017721 | 40.5092582 | 11.7951335  | .0006093845 |            |
| 2696164 | 4427101288 | 40.5215992 | 11.7975289  | .0006090134 |            |
| 2699449 | 4435194707 | 40.5339364 | 11.7999234  | .0006086427 |            |
| 2702736 | 4443297984 | 40.5462699 | 11.8023169  | .0006082725 |            |
| 2706025 | 4451411125 | 40.5585996 | 11.8047094  | .0006079027 |            |
| 2709316 | 4459534136 | 40.5709255 | 11.8071010  | .0006075334 |            |
| 2712609 | 4467667023 | 40.5832477 | 11.8094916  | .0006071645 |            |
| 2715904 | 4475809792 | 40.5955663 | 11.8118812  | .0006067961 |            |
| 2719201 | 4483962449 | 40.6078810 | 11.8142698  | .0006064281 |            |
| 2722500 | 4492125000 | 40.6201920 | 11.8166576  | .0006060606 |            |
| 2725801 | 4500297451 | 40.6324993 | 11.8190443  | .0006056985 |            |
| 2729104 | 4508479808 | 40.6448029 | 11.8214301  | .0006053269 |            |
| 2732409 | 4516672077 | 40.6571027 | 11.8238149  | .0006049607 |            |
| 2735716 | 4524874264 | 40.6693988 | 11.8261987  | .0006045949 |            |
| 2739025 | 4533086375 | 40.6816912 | 11.8285816  | .0006042296 |            |
| 2742336 | 4541308416 | 40.6939799 | 11.8309634  | .0006038647 |            |
| 2745649 | 4549540393 | 40.7062648 | 11.8333444  | .0006035003 |            |
| 2748964 | 4557782312 | 40.7185461 | 11.8357244  | .0006031363 |            |
| 2752281 | 4566034179 | 40.7308237 | 11.8381034  | .0006027728 |            |
| 2755600 | 4574296000 | 40.7430976 | 11.8404815  | .0006024096 |            |
| 2758921 | 4582567781 | 40.7553677 | 11.8428586  | .0006020470 |            |
| 2762244 | 4590849528 | 40.7676342 | 11.8452348  | .0006016847 |            |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1663 | 2765569 | 4599141247 | 40.7798970  | 11.8476100 | .0006018229 |
| 1664 | 2768896 | 4607442994 | 40.7921561  | 11.8499843 | .0006009615 |
| 1665 | 2772225 | 4615754625 | 40.8044115  | 11.8523576 | .0006006006 |
| 1666 | 2775556 | 4624076296 | 40.8166683  | 11.8547299 | .0006002401 |
| 1667 | 2778889 | 4632407963 | 40.8289113  | 11.8571014 | .0005998800 |
| 1668 | 2782224 | 4640749632 | 40.8411557  | 11.8594719 | .0005995204 |
| 1669 | 2785561 | 4649101309 | 40.8533964  | 11.8618414 | .0005991612 |
| 1670 | 2788900 | 4657463000 | 40.8656335  | 11.8642100 | .0005988024 |
| 1671 | 2792241 | 4665834711 | 40.8778669  | 11.8665776 | .0005984440 |
| 1672 | 2795584 | 4674216448 | 40.8900966  | 11.8689443 | .0005980861 |
| 1673 | 2798929 | 4682608217 | 40.9023227  | 11.8713100 | .0005977286 |
| 1674 | 2802276 | 4691010024 | 40.9145451  | 11.8736748 | .0005973716 |
| 1675 | 2805625 | 4699421875 | 40.9267638  | 11.8760387 | .0005970149 |
| 1676 | 2808976 | 4707843776 | 40.9389790  | 11.8784016 | .0005966587 |
| 1677 | 2812329 | 4716275733 | 40.9511905  | 11.8807636 | .0005963029 |
| 1678 | 2815684 | 4724717752 | 40.9633983  | 11.8831246 | .0005959476 |
| 1679 | 2819041 | 4733169839 | 40.9756025  | 11.8854847 | .0005955926 |
| 1680 | 2822400 | 4741632000 | 40.9878031  | 11.8878439 | .0005952381 |
| 1681 | 2825761 | 4750104241 | 41.0000000  | 11.8902022 | .0005948840 |
| 1682 | 2829124 | 4758586568 | 41.0121933  | 11.8925595 | .0005945303 |
| 1683 | 2832489 | 4767078987 | 41.0243830  | 11.8949159 | .0005941771 |
| 1684 | 2835856 | 4775581504 | 41.0365691  | 11.8972713 | .0005938242 |
| 1685 | 2839225 | 4784094125 | 41.0487515  | 11.8996258 | .0005934718 |
| 1686 | 2842596 | 4792616856 | 41.0609303  | 11.9019793 | .0005931198 |
| 1687 | 2845969 | 4801149703 | 41.0731055  | 11.9043319 | .0005927682 |
| 1688 | 2849344 | 4809692672 | 41.0852772  | 11.9066836 | .0005924171 |
| 1689 | 2852721 | 4818245769 | 41.0974452  | 11.9090344 | .0005920663 |
| 1690 | 2856100 | 4826809000 | 41.1096096  | 11.9113843 | .0005917160 |
| 1691 | 2859481 | 4835382371 | 41.1217704  | 11.9137332 | .0005913661 |
| 1692 | 2862864 | 4843965888 | 41.1339276  | 11.9160812 | .0005910165 |
| 1693 | 2866249 | 4852559557 | 41.1460812  | 11.9184283 | .0005906675 |
| 1694 | 2869636 | 4861163384 | 41.1582313  | 11.9207744 | .0005903188 |
| 1695 | 2873025 | 4869777375 | 41.1703777  | 11.9231196 | .0005899705 |
| 1696 | 2876416 | 4878401536 | 41.1825206  | 11.9254689 | .0005896226 |
| 1697 | 2879809 | 4887035873 | 41.1946599  | 11.9278073 | .0005892752 |
| 1698 | 2883204 | 4895680392 | 41.2067956  | 11.9301497 | .0005889282 |
| 1699 | 2886601 | 4904335099 | 41.2189277  | 11.9324913 | .0005885815 |
| 1700 | 2890000 | 4913000000 | 41.23 0563  | 11.9348319 | .0005882353 |
| 1701 | 2893401 | 4921675101 | 41.2431812  | 11.9371716 | .0005878895 |
| 1702 | 2896804 | 4930360408 | 41.2558027  | 11.9395104 | .0005875441 |
| 1703 | 2900209 | 4939055927 | 41.2674205  | 11.9418482 | .0005871991 |
| 1704 | 2903616 | 4947761664 | 41.2795349  | 11.9441852 | .0005868545 |
| 1705 | 2907025 | 4956477625 | 41.2916456  | 11.9465213 | .0005865103 |
| 1706 | 2910436 | 4965203816 | 41.3037529  | 11.9488564 | .0005861665 |
| 1707 | 2913849 | 4973940243 | 41.3158565  | 11.9511906 | .0005858231 |
| 1708 | 2917264 | 4982686912 | 41.3279566  | 11.9535239 | .0005854801 |
| 1709 | 2920681 | 4991443829 | 41.3400532  | 11.9558563 | .0005851375 |
| 1710 | 2924100 | 5000211000 | 41.3521463  | 11.9581878 | .0005847953 |
| 1711 | 2927521 | 5008988431 | 41.3642358  | 11.9605184 | .0005844535 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1712 | 2930944 | 5017776128 | 41·8763217  | 11·9628481 | ·0005841121 |
| 1713 | 2934369 | 5026574097 | 41·8884042  | 11·9651768 | ·0005837712 |
| 1714 | 2937796 | 5035382344 | 41·4004831  | 11·9675047 | ·0005834306 |
| 1715 | 2941225 | 5044200875 | 41·4125585  | 11·9698317 | ·0005830904 |
| 1716 | 2944656 | 5053029696 | 41·4246304  | 11·9721577 | ·0005827506 |
| 1717 | 2948089 | 5061868813 | 41·4366987  | 11·9744829 | ·0005824112 |
| 1718 | 2951524 | 5070718232 | 41·4487636  | 11·9768071 | ·0005820722 |
| 1719 | 2954961 | 5079577959 | 41·4608249  | 11·9791304 | ·0005817336 |
| 1720 | 2958400 | 5088448000 | 41·4728827  | 11·9814528 | ·0005813953 |
| 1721 | 2961841 | 5097328361 | 41·4849370  | 11·9837744 | ·0005810575 |
| 1722 | 2965284 | 5106219048 | 41·4969878  | 11·9860950 | ·0005807201 |
| 1723 | 2968729 | 5115120067 | 41·5090351  | 11·9884148 | ·0005803831 |
| 1724 | 2972176 | 5124031424 | 41·5210790  | 11·9907336 | ·0005800464 |
| 1725 | 2975625 | 5132953125 | 41·5331193  | 11·9930516 | ·0005797101 |
| 1726 | 2979076 | 5141885176 | 41·5451561  | 11·9953686 | ·0005793743 |
| 1727 | 2982529 | 5150827583 | 41·5571895  | 11·9976848 | ·0005790388 |
| 1728 | 2985984 | 5159780352 | 41·5692194  | 12·0000000 | ·0005787037 |
| 1729 | 2989441 | 5168743489 | 41·5812457  | 12·0023144 | ·0005783690 |
| 1730 | 2992900 | 5177717000 | 41·5932686  | 12·0046278 | ·0005780347 |
| 1731 | 2996361 | 5186700891 | 41·6052881  | 12·0069404 | ·0005777008 |
| 1732 | 2999824 | 5195695168 | 41·6173041  | 12·0092521 | ·0005773672 |
| 1733 | 3003289 | 5204699837 | 41·6293166  | 12·0115629 | ·0005770340 |
| 1734 | 3006756 | 5213714904 | 41·6413256  | 12·0138728 | ·0005767013 |
| 1735 | 3010225 | 5222740375 | 41·6533312  | 12·0161818 | ·0005763689 |
| 1736 | 3013696 | 5231776256 | 41·6653333  | 12·0184900 | ·0005760369 |
| 1737 | 3017169 | 5240822553 | 41·6773319  | 12·0207973 | ·0005757052 |
| 1738 | 3020644 | 5249879272 | 41·6893271  | 12·0231037 | ·0005753740 |
| 1739 | 3024121 | 5258946419 | 41·7013189  | 12·0254092 | ·0005750431 |
| 1740 | 3027600 | 5268024000 | 41·7133072  | 12·0277138 | ·0005747126 |
| 1741 | 3031081 | 5277112021 | 41·7252921  | 12·0300175 | ·0005743825 |
| 1742 | 3034564 | 5286210488 | 41·7372735  | 12·0323204 | ·0005740528 |
| 1743 | 3038049 | 5295319407 | 41·7492515  | 12·0346223 | ·0005737235 |
| 1744 | 3041536 | 5304438784 | 41·7612260  | 12·0369233 | ·0005733945 |
| 1745 | 3045025 | 5313568625 | 41·7731971  | 12·0392235 | ·0005730659 |
| 1746 | 3048516 | 5322708936 | 41·7851648  | 12·0415229 | ·0005727377 |
| 1747 | 3052009 | 5331859723 | 41·7971291  | 12·0438213 | ·0005724098 |
| 1748 | 3055504 | 5341020992 | 41·8090899  | 12·0461189 | ·0005720824 |
| 1749 | 3059001 | 5350192749 | 41·8210473  | 12·0484156 | ·0005717553 |
| 1750 | 3062500 | 5359375000 | 41·8330013  | 12·0507114 | ·0005714286 |
| 1751 | 3066001 | 5368567751 | 41·8449519  | 12·0530063 | ·0005711022 |
| 1752 | 3069504 | 5377771008 | 41·8568991  | 12·0553003 | ·0005707763 |
| 1753 | 3073009 | 5386984777 | 41·8688428  | 12·0575935 | ·0005704507 |
| 1754 | 3076516 | 5396209064 | 41·8807832  | 12·0598859 | ·0005701254 |
| 1755 | 3080025 | 5405443875 | 41·8927201  | 12·0621773 | ·0005698006 |
| 1756 | 3083536 | 5414689216 | 41·9046537  | 12·0644679 | ·0005694761 |
| 1757 | 3087049 | 5423945093 | 41·9165838  | 12·0667576 | ·0005691520 |
| 1758 | 3090564 | 5433211512 | 41·9285106  | 12·0690464 | ·0005688282 |
| 1759 | 3094081 | 5442488479 | 41·9404339  | 12·0713344 | ·0005685048 |
| 1760 | 3097600 | 5451776000 | 41·9523539  | 12·0736215 | ·0005681818 |



| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1761 | 8101121 | 5461074081 | 41·9642705  | 12·0759077 | ·0005678592 |
| 1762 | 8104644 | 5470382728 | 41·9761837  | 12·0781980 | ·0005675869 |
| 1763 | 8108169 | 5479701947 | 41·9880935  | 12·0804775 | ·0005672130 |
| 1764 | 8111696 | 5489031744 | 42·0000000  | 12·0827612 | ·0005668934 |
| 1765 | 8115225 | 5498372125 | 42·0119031  | 12·0850439 | ·0005665722 |
| 1766 | 8118756 | 5507723096 | 42·0238028  | 12·0873258 | ·0005662514 |
| 1767 | 8122289 | 5517084663 | 42·0356991  | 12·0896069 | ·0005659310 |
| 1768 | 8125824 | 5526456832 | 42·0475921  | 12·0918870 | ·0005656109 |
| 1769 | 8129361 | 5535839609 | 42·0594817  | 12·0941664 | ·0005652911 |
| 1770 | 8132900 | 5545233000 | 42·0713679  | 12·0964449 | ·0005649718 |
| 1771 | 8136441 | 5554637011 | 42·0832508  | 12·0987226 | ·0005646527 |
| 1772 | 8139984 | 5564051648 | 42·0951304  | 12·1009993 | ·0005643341 |
| 1773 | 8143529 | 5573476917 | 42·1070065  | 12·1032753 | ·0005640158 |
| 1774 | 8147076 | 5582912824 | 42·1188794  | 12·1055503 | ·0005636979 |
| 1775 | 8150625 | 5592359375 | 42·1307488  | 12·1078245 | ·0005633803 |
| 1776 | 8154176 | 5601816576 | 42·1426150  | 12·1100979 | ·0005630631 |
| 1777 | 8157729 | 5611284433 | 42·1544778  | 12·1123704 | ·0005627462 |
| 1778 | 8161284 | 5620762952 | 42·1663373  | 12·1146420 | ·0005624297 |
| 1779 | 8164841 | 5630252139 | 42·1781934  | 12·1169128 | ·0005621135 |
| 1780 | 8168400 | 5639752000 | 42·1900462  | 12·1191827 | ·0005617978 |
| 1781 | 8171961 | 5649262541 | 42·2018957  | 12·1214518 | ·0005614823 |
| 1782 | 8175524 | 5658783768 | 42·2137418  | 12·1237200 | ·0005611672 |
| 1783 | 8179089 | 5668315587 | 42·2255846  | 12·1259874 | ·0005608525 |
| 1784 | 8182656 | 5677858304 | 42·2374242  | 12·1282539 | ·0005605381 |
| 1785 | 8186225 | 5687411625 | 42·2492603  | 12·1305197 | ·0005602241 |
| 1786 | 8189796 | 5696975656 | 42·2610932  | 12·1327845 | ·0005599104 |
| 1787 | 8193369 | 5706550408 | 42·2729227  | 12·1350485 | ·0005595971 |
| 1788 | 8196944 | 5716135872 | 42·2847490  | 12·1373117 | ·0005592841 |
| 1789 | 8200521 | 5725732069 | 42·2965719  | 12·1395740 | ·0005589715 |
| 1790 | 8204100 | 5735339000 | 42·3083916  | 12·1418355 | ·0005586592 |
| 1791 | 8207681 | 5744956671 | 42·3202079  | 12·1440961 | ·0005583478 |
| 1792 | 8211264 | 5754585088 | 42·3320210  | 12·1463559 | ·0005580357 |
| 1793 | 8214849 | 5764224257 | 42·3438307  | 12·1486148 | ·0005577245 |
| 1794 | 8218436 | 5773874184 | 42·3556371  | 12·1508729 | ·0005574136 |
| 1795 | 8222025 | 5783534875 | 42·3674403  | 12·1531302 | ·0005571031 |
| 1796 | 8225616 | 5793206336 | 42·3792402  | 12·1553866 | ·0005567929 |
| 1797 | 8229209 | 5802888573 | 42·3910368  | 12·1576422 | ·0005564830 |
| 1798 | 8232804 | 5812581592 | 42·4028301  | 12·1598970 | ·0005561735 |
| 1799 | 8236401 | 5822285399 | 42·4146201  | 12·1621509 | ·0005558644 |
| 1800 | 8240000 | 5832000000 | 42·4264069  | 12·1644040 | ·0005555556 |
| 1801 | 8243601 | 5841725401 | 42·4381903  | 12·1666562 | ·0005552471 |
| 1802 | 8247204 | 5851461608 | 42·4499705  | 12·1689076 | ·0005549390 |
| 1803 | 8250809 | 5861208627 | 42·4617475  | 12·1711582 | ·0005546312 |
| 1804 | 8254416 | 5870966464 | 42·4735212  | 12·1734079 | ·0005543237 |
| 1805 | 8258025 | 5880735125 | 42·4852916  | 12·1756569 | ·0005540166 |
| 1806 | 8261636 | 5890514616 | 42·4970587  | 12·1779050 | ·0005537099 |
| 1807 | 8265249 | 5900304943 | 42·5088226  | 12·1801522 | ·0005534034 |
| 1808 | 8268864 | 5910106112 | 42·5205833  | 12·1823987 | ·0005530973 |
| 1809 | 8272481 | 5919918129 | 42·5323406  | 12·1846448 | ·0005527916 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal |
|------|---------|------------|-------------|------------|------------|
| 1810 | 3276100 | 5929741000 | 42.5440948  | 12.1868891 | 0005524862 |
| 1811 | 3279721 | 5989574731 | 42.5558456  | 12.1891331 | 0005521811 |
| 1812 | 3283344 | 5949419328 | 42.5675933  | 12.1913762 | 0005518764 |
| 1813 | 3286969 | 5959274797 | 42.5793377  | 12.1936185 | 0005515720 |
| 1814 | 3290596 | 5969141144 | 42.5910789  | 12.1958599 | 0005512679 |
| 1815 | 3294225 | 5979018375 | 42.6028168  | 12.1981006 | 0005509642 |
| 1816 | 3297856 | 5988906496 | 42.6145515  | 12.2003404 | 0005506608 |
| 1817 | 3301489 | 5998805513 | 42.6262829  | 12.2025794 | 0005503577 |
| 1818 | 3305124 | 6008715432 | 42.6380112  | 12.2048176 | 0005500550 |
| 1819 | 3308761 | 6018636259 | 42.6497362  | 12.2070549 | 0005497526 |
| 1820 | 3312400 | 6028568000 | 42.6614580  | 12.2092915 | 0005494505 |
| 1821 | 3316041 | 6038510661 | 42.6731766  | 12.2115272 | 0005491488 |
| 1822 | 3319684 | 6048464248 | 42.6848919  | 12.2137621 | 0005488474 |
| 1823 | 3323329 | 6058428767 | 42.6966040  | 12.2159962 | 0005485464 |
| 1824 | 3326976 | 6068404224 | 42.7083130  | 12.2182295 | 0005482456 |
| 1825 | 3330625 | 6078390625 | 42.7200187  | 12.2204620 | 0005479452 |
| 1826 | 3334276 | 6088387976 | 42.7317212  | 12.2226936 | 0005476451 |
| 1827 | 3337929 | 6098396283 | 42.7434206  | 12.2249244 | 0005473454 |
| 1828 | 3341584 | 6108415552 | 42.7551167  | 12.2271544 | 0005470460 |
| 1829 | 3345241 | 6118445789 | 42.7668095  | 12.2293836 | 0005467469 |
| 1830 | 3348900 | 6128487000 | 42.7784992  | 12.2316120 | 0005464481 |
| 1831 | 3352561 | 6138533919 | 42.7901858  | 12.2338396 | 0005461496 |
| 1832 | 3356224 | 6148602368 | 42.8018691  | 12.2360668 | 0005458515 |
| 1833 | 3359889 | 6158676537 | 42.8135492  | 12.2382928 | 0005455537 |
| 1834 | 3363556 | 6168761704 | 42.8252262  | 12.2405174 | 0005452568 |
| 1835 | 3367225 | 6178857875 | 42.8368999  | 12.2427418 | 0005449591 |
| 1836 | 3370896 | 6188965056 | 42.8485706  | 12.2449653 | 0005446623 |
| 1837 | 3374569 | 6199083253 | 42.8602380  | 12.2471880 | 0005443658 |
| 1838 | 3378244 | 6209212472 | 42.8719022  | 12.2494099 | 0005440696 |
| 1839 | 3381921 | 6219352719 | 42.8835633  | 12.2516310 | 0005437738 |
| 1840 | 3385600 | 6229504000 | 42.8952212  | 12.2538513 | 0005434783 |
| 1841 | 3389281 | 6239666321 | 42.9068759  | 12.2560708 | 0005431831 |
| 1842 | 3392964 | 6249839688 | 42.9185275  | 12.2582895 | 0005428882 |
| 1843 | 3396649 | 6260024107 | 42.9301759  | 12.2605074 | 0005425936 |
| 1844 | 3400336 | 6270219584 | 42.9418211  | 12.2627245 | 0005422998 |
| 1845 | 3404025 | 6280426125 | 42.9534632  | 12.2649408 | 0005420054 |
| 1846 | 3407716 | 6290643736 | 42.9651021  | 12.2671563 | 0005417118 |
| 1847 | 3411409 | 6300872423 | 42.9767379  | 12.2693710 | 0005414185 |
| 1848 | 3415104 | 6311112192 | 42.9883705  | 12.2715849 | 0005411255 |
| 1849 | 3418801 | 6321363049 | 43.0000000  | 12.2737980 | 0005408329 |
| 1850 | 3422500 | 6331625000 | 43.0116263  | 12.2760103 | 0005405405 |
| 1851 | 3426201 | 6341898051 | 43.0232495  | 12.2782218 | 0005402485 |
| 1852 | 3429904 | 6352182208 | 43.0348696  | 12.2804325 | 0005399568 |
| 1853 | 3433609 | 6362477477 | 43.0464865  | 12.2826424 | 0005396654 |
| 1854 | 3437316 | 6372783864 | 43.0581003  | 12.2848515 | 0005393748 |
| 1855 | 3441025 | 6383101375 | 43.0697109  | 12.2870598 | 0005390836 |
| 1856 | 3444736 | 6393430016 | 43.0813185  | 12.2892673 | 0005387931 |
| 1857 | 3448449 | 6403769793 | 43.0929228  | 12.2914740 | 0005385030 |
| 1858 | 3452164 | 6414120712 | 43.1045241  | 12.2936800 | 0005382131 |



| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1859 | 3455881 | 6424482779 | 43·1161223  | 12·2958851 | ·0005379236 |
| 1860 | 3459600 | 6434856000 | 43·1277173  | 12·2980895 | ·0005376344 |
| 1861 | 3463321 | 6445240381 | 43·1393092  | 12·3002930 | ·0005373455 |
| 1862 | 3467044 | 6455635928 | 43·1508980  | 12·3024958 | ·0005370569 |
| 1863 | 3470769 | 6466042647 | 43·1624837  | 12·3046978 | ·0005367687 |
| 1864 | 3474496 | 6476460544 | 43·1740663  | 12·3068990 | ·0005364807 |
| 1865 | 3478225 | 6486889625 | 43·1856458  | 12·3090994 | ·0005361930 |
| 1866 | 3481956 | 6497329896 | 43·1972221  | 12·3112991 | ·0005359057 |
| 1867 | 3485689 | 6507781363 | 43·2087954  | 12·3134979 | ·0005356186 |
| 1868 | 3489424 | 6518244082 | 43·2203656  | 12·3156959 | ·0005353319 |
| 1869 | 3493161 | 6528717909 | 43·2319326  | 12·3178932 | ·0005350455 |
| 1870 | 3496900 | 6539203000 | 43·2434966  | 12·3200897 | ·0005347594 |
| 1871 | 3500641 | 6549699311 | 43·2550575  | 12·3222854 | ·0005344735 |
| 1872 | 3504384 | 6560206848 | 43·2666153  | 12·3244803 | ·0005341880 |
| 1873 | 3508129 | 6570725617 | 43·2781700  | 12·3266744 | ·0005339028 |
| 1874 | 3511876 | 6581255624 | 43·2897216  | 12·3288678 | ·0005336179 |
| 1875 | 3515625 | 6591796875 | 43·3012702  | 12·3310604 | ·0005333338 |
| 1876 | 3519376 | 6602349376 | 43·3128157  | 12·3332522 | ·0005330490 |
| 1877 | 3523129 | 6612913133 | 43·3243580  | 12·3354482 | ·0005327651 |
| 1878 | 3526884 | 6623488152 | 43·3358973  | 12·3376384 | ·0005324814 |
| 1879 | 3530641 | 6634074439 | 43·3474336  | 12·3398229 | ·0005321980 |
| 1880 | 3534400 | 6644672000 | 43·3589668  | 12·3420116 | ·0005319149 |
| 1881 | 3538161 | 6655280841 | 43·3704969  | 12·3441995 | ·0005316321 |
| 1882 | 3541924 | 6665900968 | 43·3820289  | 12·3463866 | ·0005313496 |
| 1883 | 3545689 | 6676532387 | 43·3935479  | 12·3485730 | ·0005310674 |
| 1884 | 3549456 | 6687175104 | 43·4050688  | 12·3507586 | ·0005307856 |
| 1885 | 3553225 | 6697829125 | 43·4165867  | 12·3529434 | ·0005305040 |
| 1886 | 3556996 | 6708494456 | 43·4281015  | 12·3551274 | ·0005302227 |
| 1887 | 3560769 | 6719171103 | 43·4396132  | 12·3573107 | ·0005299417 |
| 1888 | 3564544 | 6729859072 | 43·4511220  | 12·3594932 | ·0005296610 |
| 1889 | 3568321 | 6740558369 | 43·4626276  | 12·3616749 | ·0005293806 |
| 1890 | 3572100 | 6751269000 | 43·4741302  | 12·3638559 | ·0005291005 |
| 1891 | 3575881 | 6761990971 | 43·4856298  | 12·3660361 | ·0005288207 |
| 1892 | 3579664 | 6772724288 | 43·4971263  | 12·3682155 | ·0005285412 |
| 1893 | 3583449 | 6783468957 | 43·5086198  | 12·3703941 | ·0005282620 |
| 1894 | 3587236 | 6794224984 | 43·5201103  | 12·3725721 | ·0005279831 |
| 1895 | 3591025 | 6804992375 | 43·5315977  | 12·3747492 | ·0005277045 |
| 1896 | 3594816 | 6815771136 | 43·5430821  | 12·3769255 | ·0005274262 |
| 1897 | 3598609 | 6826561273 | 43·5545635  | 12·3791011 | ·0005271481 |
| 1898 | 3602404 | 6837362792 | 43·5660418  | 12·3812759 | ·0005268704 |
| 1899 | 3606201 | 6848175699 | 43·5775171  | 12·3834500 | ·0005265929 |
| 1900 | 3610000 | 6859000000 | 43·5889894  | 12·3856233 | ·0005263158 |
| 1901 | 3613801 | 6869835701 | 43·6004587  | 12·3877959 | ·0005260389 |
| 1902 | 3617604 | 6880682808 | 43·6119249  | 12·3899676 | ·0005257624 |
| 1903 | 3621409 | 6891541327 | 43·6233882  | 12·3921386 | ·0005254861 |
| 1904 | 3625216 | 6902411264 | 43·6348485  | 12·3943089 | ·0005252101 |
| 1905 | 3629025 | 6913292625 | 43·6463057  | 12·3964784 | ·0005249344 |
| 1906 | 3632836 | 6924185416 | 43·6577599  | 12·3986471 | ·0005246590 |
| 1907 | 3636649 | 6935089643 | 43·6692111  | 12·4008151 | ·0005243838 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1908 | 3640464 | 6946005312 | 43.6806593  | 12.4029823 | .0005241090 |
| 1909 | 3644281 | 6956932429 | 43.6921045  | 12.4051488 | .0005238345 |
| 1910 | 3648100 | 6967871000 | 43.7035467  | 12.4073145 | .0005235602 |
| 1911 | 3651921 | 6978821031 | 43.7149860  | 12.4094794 | .0005232862 |
| 1912 | 3655744 | 6989782528 | 43.7264222  | 12.4116436 | .0005230126 |
| 1913 | 3659569 | 7000755497 | 43.7378554  | 12.4138070 | .0005227392 |
| 1914 | 3663396 | 7011739944 | 43.7492857  | 12.4159697 | .0005224660 |
| 1915 | 3667225 | 7022735875 | 43.7607129  | 12.4181316 | .0005221932 |
| 1916 | 3671056 | 7033743296 | 43.7721373  | 12.4202928 | .0005219207 |
| 1917 | 3674889 | 7044762213 | 43.7835585  | 12.4224533 | .0005216484 |
| 1918 | 3678724 | 7055792632 | 43.7949768  | 12.4246129 | .0005213764 |
| 1919 | 3682561 | 7066834559 | 43.8063922  | 12.4267719 | .0005211047 |
| 1920 | 3686400 | 7077888000 | 43.8178046  | 12.4289300 | .0005208333 |
| 1921 | 3690241 | 7088952961 | 43.8292140  | 12.4310875 | .0005205622 |
| 1922 | 3694084 | 7100029448 | 43.8406204  | 12.4332441 | .0005202914 |
| 1923 | 3697929 | 7111117467 | 43.8520239  | 12.4354001 | .0005200208 |
| 1924 | 3701776 | 7122217024 | 43.8634244  | 12.4375552 | .0005197505 |
| 1925 | 3705625 | 7133328125 | 43.8748219  | 12.4397097 | .0005194805 |
| 1926 | 3709476 | 7144450776 | 43.8862165  | 12.4418634 | .0005192108 |
| 1927 | 3713329 | 7155584983 | 43.8976081  | 12.4440163 | .0005189414 |
| 1928 | 3717184 | 7166730752 | 43.9089968  | 12.4461685 | .0005186722 |
| 1929 | 3721041 | 7177888089 | 43.9203725  | 12.4483200 | .0005184033 |
| 1930 | 3724900 | 7189057000 | 43.9317652  | 12.4504707 | .0005181347 |
| 1931 | 3728761 | 7200237491 | 43.9431451  | 12.4526206 | .0005178664 |
| 1932 | 3732624 | 7211429568 | 43.9545220  | 12.4547699 | .0005175983 |
| 1933 | 3736489 | 7222633237 | 43.9658959  | 12.4569184 | .0005173306 |
| 1934 | 3740356 | 7233848504 | 43.9772668  | 12.4590661 | .0005170631 |
| 1935 | 3744225 | 7245075375 | 43.9886349  | 12.4612131 | .0005167959 |
| 1936 | 3748096 | 7256318856 | 44.0000000  | 12.4633594 | .0005165289 |
| 1937 | 3751969 | 7267563953 | 44.0113622  | 12.4655049 | .0005162623 |
| 1938 | 3755844 | 7278825672 | 44.0227214  | 12.4676497 | .0005159959 |
| 1939 | 3759721 | 7290099019 | 44.0340777  | 12.4697937 | .0005157298 |
| 1940 | 3763600 | 7301384000 | 44.0454311  | 12.4719370 | .0005154639 |
| 1941 | 3767481 | 7312680621 | 44.0567815  | 12.4740796 | .0005151984 |
| 1942 | 3771364 | 7323988888 | 44.0681291  | 12.4762214 | .0005149331 |
| 1943 | 3775249 | 7335308807 | 44.0794737  | 12.4783625 | .0005146680 |
| 1944 | 3779136 | 7346640384 | 44.0908154  | 12.4805029 | .0005144033 |
| 1945 | 3783025 | 7357983625 | 44.1021541  | 12.4826426 | .0005141388 |
| 1946 | 3786916 | 7369338536 | 44.1134900  | 12.4847815 | .0005138746 |
| 1947 | 3790809 | 7380705123 | 44.1248229  | 12.4869197 | .0005136107 |
| 1948 | 3794704 | 7392083392 | 44.1361530  | 12.4890571 | .0005133470 |
| 1949 | 3798601 | 7403473349 | 44.1474801  | 12.4911938 | .0005130836 |
| 1950 | 3802500 | 7414875000 | 44.1588043  | 12.4933298 | .0005128205 |
| 1951 | 3806401 | 7426288351 | 44.1701256  | 12.4954651 | .0005125577 |
| 1952 | 3810304 | 7437713408 | 44.1814441  | 12.4975995 | .0005122951 |
| 1953 | 3814209 | 7449150177 | 44.1927596  | 12.4997333 | .0005120328 |
| 1954 | 3818116 | 7460598664 | 44.2040722  | 12.5018664 | .0005117707 |
| 1955 | 3822025 | 7472058875 | 44.2153819  | 12.5039988 | .0005115090 |
| 1956 | 3825936 | 7483530816 | 44.2266888  | 12.5061304 | .0005112474 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 1957 | 3829849 | 7495014493 | 44·2379927  | 12·5082612 | ·0005109862 |
| 1958 | 3833764 | 7506509912 | 44·2492938  | 12·5103914 | ·0005107252 |
| 1959 | 3837681 | 7518017079 | 44·2605919  | 12·5125208 | ·0005104645 |
| 1960 | 3841600 | 7529536000 | 44·2718872  | 12·5146495 | ·0005102041 |
| 1961 | 3845521 | 7541066681 | 44·2831797  | 12·5167775 | ·0005099489 |
| 1962 | 3849444 | 7552609128 | 44·2944692  | 12·5189047 | ·0005096840 |
| 1963 | 3853369 | 7564163347 | 44·3057558  | 12·5210313 | ·0005094244 |
| 1964 | 3857296 | 7575729344 | 44·3170396  | 12·5231571 | ·0005091650 |
| 1965 | 3861225 | 7587307125 | 44·3283205  | 12·5252822 | ·0005089059 |
| 1966 | 3865156 | 7598896696 | 44·3395985  | 12·5274065 | ·0005086470 |
| 1967 | 3869089 | 7610498063 | 44·3508737  | 12·5295302 | ·0005083884 |
| 1968 | 3873024 | 7622111232 | 44·3621460  | 12·5316531 | ·0005081301 |
| 1969 | 3876961 | 7633736209 | 44·3734155  | 12·5337753 | ·0005078720 |
| 1970 | 3880900 | 7645373000 | 44·3846820  | 12·5358968 | ·0005076142 |
| 1971 | 3884841 | 7657021611 | 44·3959457  | 12·5380176 | ·0005073567 |
| 1972 | 3888784 | 7668682048 | 44·4072066  | 12·5401877 | ·0005070994 |
| 1973 | 3892729 | 7680354317 | 44·4184646  | 12·5422570 | ·0005068424 |
| 1974 | 3896676 | 7692038424 | 44·4297198  | 12·5443757 | ·0005065856 |
| 1975 | 3900625 | 7703734375 | 44·4409720  | 12·5464936 | ·0005063291 |
| 1976 | 3904576 | 7715442176 | 44·4522215  | 12·5486107 | ·0005060729 |
| 1977 | 3908529 | 7727161833 | 44·4634681  | 12·5507272 | ·0005058169 |
| 1978 | 3912484 | 7738893352 | 44·4747119  | 12·5528480 | ·0005055612 |
| 1979 | 3916441 | 7750636739 | 44·4859528  | 12·5549580 | ·0005053057 |
| 1980 | 3920400 | 7762392000 | 44·4971909  | 12·5570723 | ·0005050505 |
| 1981 | 3924361 | 7774159141 | 44·5084262  | 12·5591860 | ·0005047956 |
| 1982 | 3928324 | 7785938168 | 44·5196586  | 12·5612989 | ·0005045409 |
| 1983 | 3932289 | 7797729087 | 44·5308881  | 12·5634111 | ·0005042864 |
| 1984 | 3936256 | 7809531904 | 44·5421149  | 12·5655226 | ·0005040323 |
| 1985 | 3940225 | 7821346625 | 44·5533388  | 12·5676384 | ·0005037783 |
| 1986 | 3944196 | 7833173256 | 44·5645599  | 12·5697485 | ·0005035247 |
| 1987 | 3948169 | 7845011803 | 44·5757781  | 12·5718529 | ·0005032713 |
| 1988 | 3952144 | 7856862272 | 44·5869936  | 12·5739615 | ·0005030181 |
| 1989 | 3956121 | 7868724669 | 44·5982062  | 12·5760695 | ·0005027652 |
| 1990 | 3960100 | 7880599000 | 44·6094160  | 12·5781767 | ·0005025126 |
| 1991 | 3964081 | 7892485271 | 44·6206230  | 12·5802832 | ·0005022602 |
| 1992 | 3968064 | 7904383488 | 44·6318272  | 12·5823891 | ·0005020080 |
| 1993 | 3972049 | 7916293657 | 44·6430286  | 12·5844942 | ·0005017561 |
| 1994 | 3976036 | 7928215784 | 44·6542271  | 12·5865987 | ·0005015045 |
| 1995 | 3980025 | 7940149875 | 44·6654228  | 12·5887024 | ·0005012531 |
| 1996 | 3984016 | 7952095936 | 44·6766158  | 12·5908054 | ·0005010020 |
| 1997 | 3988009 | 7964053973 | 44·6878059  | 12·5929078 | ·0005007511 |
| 1998 | 3992004 | 7976023992 | 44·6989933  | 12·5950094 | ·0005005005 |
| 1999 | 3996001 | 7988005999 | 44·7101778  | 12·5971103 | ·0005002501 |
| 2000 | 4000000 | 8000000000 | 44·7213596  | 12·5992105 | ·0005000000 |
| 2001 | 4004001 | 8012006001 | 44·7325385  | 12·6013101 | ·0004997501 |
| 2002 | 4008004 | 8024024008 | 44·7437146  | 12·6034089 | ·0004995005 |
| 2003 | 4012009 | 8036054027 | 44·7548880  | 12·6055070 | ·0004992511 |
| 2004 | 4016016 | 8048096064 | 44·7660586  | 12·6076044 | ·0004990020 |
| 2005 | 4020025 | 8060150125 | 44·7772264  | 12·6097011 | ·0004987531 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 2006 | 4024086 | 8072216216 | 44.7883913  | 12.6117971 | .0004985045 |
| 2007 | 4028049 | 8084294343 | 44.7995535  | 12.6138924 | .0004982561 |
| 2008 | 4032064 | 8096384512 | 44.8107130  | 12.6159870 | .0004980080 |
| 2009 | 4036081 | 8108486729 | 44.8218697  | 12.6180810 | .0004977601 |
| 2010 | 4040100 | 8120601000 | 44.8330235  | 12.6201743 | .0004975124 |
| 2011 | 4044121 | 8132727331 | 44.8441746  | 12.6222669 | .0004972650 |
| 2012 | 4048144 | 8144865728 | 44.8553230  | 12.6243587 | .0004970179 |
| 2013 | 4052169 | 8157016197 | 44.8664685  | 12.6264499 | .0004967710 |
| 2014 | 4056196 | 8169178744 | 44.8776113  | 12.6285404 | .0004965243 |
| 2015 | 4060225 | 8181353375 | 44.8887514  | 12.6306301 | .0004962779 |
| 2016 | 4064256 | 8193540096 | 44.8998886  | 12.6327192 | .0004960317 |
| 2017 | 4068289 | 8205738913 | 44.9110231  | 12.6348076 | .0004957858 |
| 2018 | 4072324 | 8217949832 | 44.9221549  | 12.6368953 | .0004955401 |
| 2019 | 4076361 | 8230172859 | 44.9332839  | 12.6389823 | .0004952947 |
| 2020 | 4080400 | 8242408000 | 44.9444101  | 12.6410687 | .0004950495 |
| 2021 | 4084441 | 8254655261 | 44.9555336  | 12.6431543 | .0004948046 |
| 2022 | 4088484 | 8266914648 | 44.9666543  | 12.6452393 | .0004945598 |
| 2023 | 4092529 | 8279186167 | 44.9777723  | 12.6473235 | .0004943154 |
| 2024 | 4096576 | 8291469824 | 44.9888875  | 12.6494071 | .0004940711 |
| 2025 | 4100625 | 8303765625 | 45.0000000  | 12.6514900 | .0004938272 |
| 2026 | 4104676 | 8316073576 | 45.0111097  | 12.6535722 | .0004935834 |
| 2027 | 4108729 | 8328393683 | 45.0222167  | 12.6556538 | .0004933399 |
| 2028 | 4112784 | 8340725952 | 45.0333210  | 12.6577346 | .0004930966 |
| 2029 | 4116841 | 8353070389 | 45.0444225  | 12.6598148 | .0004928536 |
| 2030 | 4120900 | 8365427000 | 45.0555213  | 12.6618943 | .0004926108 |
| 2031 | 4124961 | 8377795791 | 45.0666173  | 12.6639731 | .0004923688 |
| 2032 | 4129024 | 8390176768 | 45.0777107  | 12.6660512 | .0004921260 |
| 2033 | 4133089 | 8402569937 | 45.0888013  | 12.6681286 | .0004918839 |
| 2034 | 4137156 | 8414975304 | 45.0998891  | 12.6702053 | .0004916421 |
| 2035 | 4141225 | 8427392875 | 45.1109743  | 12.6722814 | .0004914005 |
| 2036 | 4145296 | 8439822656 | 45.1220567  | 12.6743567 | .0004911591 |
| 2037 | 4149369 | 8452264653 | 45.1331364  | 12.6764314 | .0004909180 |
| 2038 | 4153444 | 8464718872 | 45.1442134  | 12.6785054 | .0004906771 |
| 2039 | 4157521 | 8477185319 | 45.1552876  | 12.6805788 | .0004904365 |
| 2040 | 4161600 | 8489664000 | 45.1663592  | 12.6826514 | .0004901961 |
| 2041 | 4165681 | 8502154921 | 45.1774280  | 12.6847284 | .0004899559 |
| 2042 | 4169764 | 8514658088 | 45.1884941  | 12.6867947 | .0004897160 |
| 2043 | 4173849 | 8527173507 | 45.1995575  | 12.6888654 | .0004894762 |
| 2044 | 4177936 | 8539701181 | 45.2106182  | 12.6909354 | .0004892368 |
| 2045 | 4182025 | 8552241125 | 45.2216762  | 12.6930047 | .0004889976 |
| 2046 | 4186116 | 8564793336 | 45.2327315  | 12.6950733 | .0004887586 |
| 2047 | 4190209 | 8577357823 | 45.2437841  | 12.6971412 | .0004885198 |
| 2048 | 4194304 | 8589934592 | 45.2548340  | 12.6992084 | .0004882813 |
| 2049 | 4198401 | 8602523649 | 45.2658812  | 12.7012750 | .0004880429 |
| 2050 | 4202500 | 8615125000 | 45.2769257  | 12.7033409 | .0004878049 |
| 2051 | 4206601 | 8627738651 | 45.2879675  | 12.7054061 | .0004875670 |
| 2052 | 4210704 | 8640364608 | 45.2990066  | 12.7074707 | .0004873294 |
| 2053 | 4214809 | 8653002877 | 45.3100430  | 12.7095346 | .0004870921 |
| 2054 | 4218916 | 8665653464 | 45.3210768  | 12.7115978 | .0004868549 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 2055 | 4223025 | 8678316375 | 45.3321078  | 12.7136603 | .0004866180 |
| 2056 | 4227136 | 8690991616 | 45.3431362  | 12.7157222 | .0004863818 |
| 2057 | 4231249 | 8703679193 | 45.3541619  | 12.7177835 | .0004861449 |
| 2058 | 4235364 | 8716379112 | 45.3651849  | 12.7198441 | .0004859086 |
| 2059 | 4239481 | 8729091379 | 45.3762052  | 12.7219040 | .0004856727 |
| 2060 | 4243600 | 8741816000 | 45.3872229  | 12.7239632 | .0004854369 |
| 2061 | 4247721 | 8754552981 | 45.3982378  | 12.7260218 | .0004852014 |
| 2062 | 4251844 | 8767302328 | 45.4092501  | 12.7280797 | .0004849661 |
| 2063 | 4255969 | 8780064017 | 45.4202598  | 12.7301370 | .0004847310 |
| 2064 | 4260096 | 8792838144 | 45.4312668  | 12.7321935 | .0004844961 |
| 2065 | 4264225 | 8805624625 | 45.4422711  | 12.7342494 | .0004842615 |
| 2066 | 4268356 | 8818423496 | 45.4532727  | 12.7363046 | .0004840271 |
| 2067 | 4272489 | 8831234763 | 45.4642717  | 12.7383592 | .0004837929 |
| 2068 | 4276624 | 8844058432 | 45.4752680  | 12.7404131 | .0004835590 |
| 2069 | 4280761 | 8856894509 | 45.4862616  | 12.7424664 | .0004833258 |
| 2070 | 4284900 | 8869743000 | 45.4972526  | 12.7445189 | .0004830918 |
| 2071 | 4289041 | 8882603911 | 45.5082410  | 12.7465709 | .0004828585 |
| 2072 | 4293184 | 8895477248 | 45.5192267  | 12.7486222 | .0004826255 |
| 2073 | 4297329 | 8908363017 | 45.5302097  | 12.7506728 | .0004823927 |
| 2074 | 4301476 | 8921261224 | 45.5411901  | 12.7527227 | .0004821601 |
| 2075 | 4305625 | 8934171875 | 45.5521679  | 12.7547721 | .0004819277 |
| 2076 | 4309776 | 8947094976 | 45.5631430  | 12.7568207 | .0004816956 |
| 2077 | 4313929 | 8960030533 | 45.5741155  | 12.7588687 | .0004814636 |
| 2078 | 4318084 | 8972978552 | 45.5850853  | 12.7609160 | .0004812320 |
| 2079 | 4322241 | 8985939039 | 45.5960525  | 12.7629627 | .0004810005 |
| 2080 | 4326400 | 8998912000 | 45.6070170  | 12.7650087 | .0004807692 |
| 2081 | 4330561 | 9011897441 | 45.6179789  | 12.7670540 | .0004805382 |
| 2082 | 4334724 | 9024895368 | 45.6289382  | 12.7690987 | .0004803074 |
| 2083 | 4338889 | 9037905787 | 45.6398948  | 12.7711427 | .0004800768 |
| 2084 | 4343056 | 9050928704 | 45.6508488  | 12.7731861 | .0004798464 |
| 2085 | 4347225 | 9063964125 | 45.6618002  | 12.7752288 | .0004796163 |
| 2086 | 4351396 | 9077012056 | 45.6727490  | 12.7772709 | .0004793864 |
| 2087 | 4355569 | 9090072503 | 45.6836951  | 12.7793123 | .0004791567 |
| 2088 | 4359744 | 9103145472 | 45.6946386  | 12.7813531 | .0004789272 |
| 2089 | 4363921 | 9116230969 | 45.7055795  | 12.7833932 | .0004786979 |
| 2090 | 4368100 | 9129329000 | 45.7165178  | 12.7854326 | .0004784689 |
| 2091 | 4372281 | 9142439571 | 45.7274534  | 12.7874714 | .0004782401 |
| 2092 | 4376464 | 9155562688 | 45.7383865  | 12.7895096 | .0004780115 |
| 2093 | 4380649 | 9168698357 | 45.7493169  | 12.7915471 | .0004777831 |
| 2094 | 4384836 | 9181846584 | 45.7602447  | 12.7935840 | .0004775549 |
| 2095 | 4389025 | 9195007375 | 45.7711699  | 12.7956202 | .0004773270 |
| 2096 | 4393216 | 9208180736 | 45.7820926  | 12.7976558 | .0004770992 |
| 2097 | 4397409 | 9221366673 | 45.7930126  | 12.7996907 | .0004768717 |
| 2098 | 4401604 | 9234565192 | 45.8039299  | 12.8017250 | .0004766444 |
| 2099 | 4405801 | 9247776299 | 45.8148447  | 12.8037586 | .0004764173 |
| 2100 | 4410000 | 9261000000 | 45.8257569  | 12.8057916 | .0004761905 |
| 2101 | 4414201 | 9274236301 | 45.8366665  | 12.8078239 | .0004759638 |
| 2102 | 4418404 | 9287485208 | 45.8475735  | 12.8098556 | .0004757374 |
| 2103 | 4422609 | 9300746727 | 45.8584779  | 12.8118866 | .0004755112 |

| No.  | Square  | Cube       | Square Root | Cube Root  | Reciprocal  |
|------|---------|------------|-------------|------------|-------------|
| 2104 | 4426816 | 9814020864 | 45.8693798  | 12.8139170 | .0004752852 |
| 2105 | 4431025 | 9327807625 | 45.8802790  | 12.8159468 | .0004750594 |
| 2106 | 4435236 | 9340607016 | 45.8911756  | 12.8179759 | .0004748338 |
| 2107 | 4439449 | 9353919043 | 45.9020696  | 12.8200044 | .0004746084 |
| 2108 | 4443664 | 9367248712 | 45.9129611  | 12.8220323 | .0004743833 |
| 2109 | 4447881 | 9380581029 | 45.9238500  | 12.8240595 | .0004741584 |
| 2110 | 4452100 | 9393931000 | 45.9347363  | 12.8260861 | .0004739336 |
| 2111 | 4456321 | 9407293631 | 45.9456200  | 12.8281120 | .0004737091 |
| 2112 | 4460544 | 9420668928 | 45.9565012  | 12.8301373 | .0004734848 |
| 2113 | 4464769 | 9434056897 | 45.9673798  | 12.8321620 | .0004732608 |
| 2114 | 4468996 | 9447457544 | 45.9782557  | 12.8341860 | .0004730369 |
| 2115 | 4473225 | 9460870875 | 45.9891291  | 12.8362094 | .0004728132 |
| 2116 | 4477456 | 9474296896 | 46.0000000  | 12.8382321 | .0004725898 |
| 2117 | 4481689 | 9487735613 | 46.0108683  | 12.8402542 | .0004723666 |
| 2118 | 4485924 | 9501187032 | 46.0217340  | 12.8422756 | .0004721435 |
| 2119 | 4490161 | 9514651159 | 46.0325971  | 12.8442964 | .0004719207 |
| 2120 | 4494400 | 9528128000 | 46.0434577  | 12.8463166 | .0004716981 |
| 2121 | 4498641 | 9541617561 | 46.0543158  | 12.8483361 | .0004714757 |
| 2122 | 4502884 | 9555119848 | 46.0651712  | 12.8503551 | .0004712535 |
| 2123 | 4507129 | 9568634867 | 46.0760241  | 12.8523733 | .0004710316 |
| 2124 | 4511376 | 9582162624 | 46.0868745  | 12.8543910 | .0004708098 |
| 2125 | 4515625 | 9595703125 | 46.0977223  | 12.8564080 | .0004705882 |
| 2126 | 4519876 | 9609256876 | 46.1085675  | 12.8584243 | .0004703669 |
| 2127 | 4524129 | 9622822383 | 46.1194102  | 12.8604401 | .0004701457 |
| 2128 | 4528384 | 9636401152 | 46.1302504  | 12.8624552 | .0004699248 |
| 2129 | 4532641 | 9649992689 | 46.1410880  | 12.8644697 | .0004697041 |
| 2130 | 4536900 | 9663597000 | 46.1519230  | 12.8664835 | .0004694836 |
| 2131 | 4541161 | 9677214091 | 46.1627555  | 12.8684967 | .0004692633 |
| 2132 | 4545424 | 9690843968 | 46.1735855  | 12.8705093 | .0004690432 |
| 2133 | 4549689 | 9704486637 | 46.1844130  | 12.8725213 | .0004688233 |
| 2134 | 4553956 | 9718142104 | 46.1952378  | 12.8745326 | .0004686036 |
| 2135 | 4558225 | 9731810875 | 46.2060602  | 12.8765433 | .0004683841 |
| 2136 | 4562496 | 9745491456 | 46.2168800  | 12.8785534 | .0004681648 |
| 2137 | 4566769 | 9759185853 | 46.2276973  | 12.8805628 | .0004679457 |
| 2138 | 4571044 | 9772892072 | 46.2385121  | 12.8825717 | .0004677268 |
| 2139 | 4575321 | 9786611619 | 46.2493243  | 12.8845199 | .0004675082 |
| 2140 | 4579600 | 9800344000 | 46.2601340  | 12.8865374 | .0004672897 |
| 2141 | 4583881 | 9814089221 | 46.2709412  | 12.8885544 | .0004670715 |
| 2142 | 4588164 | 9827847288 | 46.2817459  | 12.8906007 | .0004668534 |
| 2143 | 4592449 | 9841618207 | 46.2925480  | 12.8926064 | .0004666356 |
| 2144 | 4596736 | 9855401984 | 46.3033476  | 12.8946115 | .0004664179 |
| 2145 | 4601025 | 9869198625 | 46.3141447  | 12.8966159 | .0004662005 |
| 2146 | 4605316 | 9883008136 | 46.3249393  | 12.8986197 | .0004659832 |
| 2147 | 4609609 | 9896830523 | 46.3357314  | 12.9006229 | .0004657662 |
| 2148 | 4613904 | 9910665792 | 46.3465209  | 12.9026255 | .0004655498 |
| 2149 | 4618201 | 9924513919 | 46.3573079  | 12.9046275 | .0004653327 |
| 2150 | 4622500 | 9938375000 | 46.3680924  | 12.9066288 | .0004651168 |
| 2151 | 4626801 | 9952248951 | 46.3788745  | 12.9086295 | .0004649000 |
| 2152 | 4631104 | 9966135808 | 46.3896540  | 12.9106296 | .0004646840 |



| No.  | Square  | Cube        | Square Root | Cube Root  | Reciprocal  |
|------|---------|-------------|-------------|------------|-------------|
| 2153 | 4635409 | 9980035577  | 46.4004310  | 12.9126291 | .0004644682 |
| 2154 | 4639716 | 9993948264  | 46.4112055  | 12.9146279 | .0004642526 |
| 2155 | 4644025 | 10007873875 | 46.4219775  | 12.9166262 | .0004640371 |
| 2156 | 4648336 | 10021812416 | 46.4327471  | 12.9186238 | .0004638219 |
| 2157 | 4652649 | 10035763893 | 46.4435141  | 12.9206208 | .0004636069 |
| 2158 | 4656964 | 10049728312 | 46.4542786  | 12.9226172 | .0004633920 |
| 2159 | 4661281 | 10063705679 | 46.4650406  | 12.9246129 | .0004631774 |
| 2160 | 4665600 | 10077696000 | 46.4758002  | 12.9266081 | .0004629630 |
| 2161 | 4669921 | 10091699281 | 46.4865572  | 12.9286027 | .0004627487 |
| 2162 | 4674244 | 10105715528 | 46.4973118  | 12.9305966 | .0004625347 |
| 2163 | 4678569 | 10119744747 | 46.5080638  | 12.9325899 | .0004623209 |
| 2164 | 4682896 | 10133786944 | 46.5188134  | 12.9345827 | .0004621072 |
| 2165 | 4687225 | 10147842125 | 46.5295605  | 12.9365747 | .0004618938 |
| 2166 | 4691556 | 10161910296 | 46.5403051  | 12.9385662 | .0004616805 |
| 2167 | 4695889 | 10175991463 | 46.5510472  | 12.9405570 | .0004614675 |
| 2168 | 4700224 | 10190085632 | 46.5617869  | 12.9425472 | .0004612546 |
| 2169 | 4704561 | 10204192809 | 46.5725241  | 12.9445369 | .0004610420 |
| 2170 | 4708900 | 10218313000 | 46.5832588  | 12.9465259 | .0004608295 |
| 2171 | 4713241 | 10232446211 | 46.5939910  | 12.9485143 | .0004606172 |
| 2172 | 4717584 | 10246592448 | 46.6047208  | 12.9505021 | .0004604052 |
| 2173 | 4721929 | 10260751717 | 46.6154481  | 12.9524893 | .0004601933 |
| 2174 | 4726276 | 10274924024 | 46.6261729  | 12.9544759 | .0004599816 |
| 2175 | 4730625 | 10289109375 | 46.6368953  | 12.9564618 | .0004597701 |
| 2176 | 4734976 | 10303307776 | 46.6476152  | 12.9584472 | .0004595588 |
| 2177 | 4739329 | 10317519233 | 46.6583326  | 12.9604319 | .0004593477 |
| 2178 | 4743684 | 10331743752 | 46.6690476  | 12.9624161 | .0004591368 |
| 2179 | 4748041 | 10345981339 | 46.6797601  | 12.9643996 | .0004589261 |
| 2180 | 4752400 | 10360232000 | 46.6904701  | 12.9663826 | .0004587156 |
| 2181 | 4756761 | 10374495741 | 46.7011777  | 12.9683649 | .0004585053 |
| 2182 | 4761124 | 10388772568 | 46.7118829  | 12.9703466 | .0004582951 |
| 2183 | 4765489 | 10403062487 | 46.7225855  | 12.9723277 | .0004580852 |
| 2184 | 4769856 | 10417365504 | 46.7332858  | 12.9743082 | .0004578755 |
| 2185 | 4774225 | 10431681625 | 46.7439836  | 12.9762881 | .0004576659 |
| 2186 | 4778596 | 10446010856 | 46.7546789  | 12.9782674 | .0004574565 |
| 2187 | 4782969 | 10460353208 | 46.7653718  | 12.9802461 | .0004572474 |
| 2188 | 4787344 | 10474708672 | 46.7760623  | 12.9822242 | .0004570384 |
| 2189 | 4791721 | 10489077269 | 46.7867503  | 12.9842017 | .0004568296 |
| 2190 | 4796100 | 10503459000 | 46.7974358  | 12.9861786 | .0004566210 |
| 2191 | 4800481 | 10517853871 | 46.8081189  | 12.9881549 | .0004564126 |
| 2192 | 4804864 | 10532261888 | 46.8187996  | 12.9901306 | .0004562044 |
| 2193 | 4809249 | 10546683057 | 46.8294779  | 12.9921057 | .0004559964 |
| 2194 | 4813636 | 10561117384 | 46.8401587  | 12.9940802 | .0004557885 |
| 2195 | 4818025 | 10575564875 | 46.8508271  | 12.9960540 | .0004555809 |
| 2196 | 4822416 | 10590025536 | 46.8614981  | 12.9980273 | .0004553734 |
| 2197 | 4826809 | 10604499373 | 46.8721666  | 13.0000000 | .0004551661 |
| 2198 | 4831204 | 10618986392 | 46.8828327  | 13.0019721 | .0004549591 |
| 2199 | 4835601 | 10633486599 | 46.8934963  | 13.0039436 | .0004547522 |
| 2200 | 4840000 | 10648000000 | 46.9041576  | 13.0059145 | .0004545455 |
| 2201 | 4844401 | 10662526601 | 46.9148164  | 13.0078848 | .0004543389 |

## EVOLUTION.

## TO EXTRACT THE SQUARE ROOT.

**RULE.**—If there be decim ls in the given number, make them to consist of two, four, six, &c., places by annexing ciphers to the right hand; then separate the whole into periods of two figures each, beginning at the right hand, and the left-hand period will consist of one or two figures, according as the number of figures in the whole number is odd or even. Find a square number equal to or the next less than the left-hand period, and put the root of it in the quotient; subtract this square from the left-hand period, and to the remainder bring down the next period for a dividend, and to the left hand of it write double the quotient for a divisor; then consider what figure if annexed to the divisor and the result multiplied by it the product may be equal to or the next less number than the dividend, and it will be the second figure of the root. From the dividend subtract the product, and to the remainder bring down the next period for a new dividend; double the figures in the quotient for a divisor, and continue the operation as above till all the periods are used.

*Example 1.**Example 2.*

Extract the sq. root of 10291264. Extract the sq. root of 177746.56.

$$\begin{array}{r|l}
 10291264 & 3208. \text{ Ans.} \\
 9 & \\
 \hline
 62 & 129 \\
 20 & 124 \\
 \hline
 6408 & 51264 \\
 & 51264 \\
 \hline
 \end{array}$$

$$\begin{array}{r|l}
 177746.56 & 421.6. \text{ Ans.} \\
 16 & \\
 \hline
 82 & 177 \\
 2 & 164 \\
 \hline
 841 & 1346 \\
 1 & 841 \\
 \hline
 8426 & 50556 \\
 & 50556 \\
 \hline
 \end{array}$$

## TO EXTRACT THE SQUARE ROOT OF A VULGAR FRACTION.

**RULE 1.**—Multiply the numerator by the denominator, and extract the square root of the product; the numerator of the given fraction, written above this root, or the denominator written below it, will express the root of any fraction when reduced to its lowest terms

That is—

$$\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}} = \frac{\sqrt{ab}}{b} = \frac{a}{\sqrt{ab}} = \frac{1}{b} \sqrt{(ab)}.$$

**RULE 2.**—Reduce the given fraction to its lowest terms; then extract the square root of the numerator for a new numerator,



and the square root of the denominator for a new denominator. If the fraction will not extract even, reduce it to a decimal and then extract the square root.

### TO EXTRACT THE CUBE ROOT.

**RULE.**—If there be decimals in the given number, make them to consist of three, six, nine, &c., places by annexing ciphers to the right hand, if necessary; then separate the whole into periods of three figures each, beginning at the right hand. The left-hand period may consist of one, two, or three figures. Find the nearest cube to the first period, subtract it therefrom, and put the root in the quotient; then thrice the square of this root will be the trial divisor for finding the next figure. Multiply the root figure, or figures already found, by three, and prefix the product to the next new root-figure (which will be seen by the trial divisor); then multiply this number by the aforesaid new root-figure, and place the product two figures to the right below the trial divisor, and add it to the trial divisor: this sum will be the true divisor. Under this divisor write the square of the last root-figure, which add to the two sums above, and the result is the next trial divisor; the true divisor being found as before directed.

#### Example.

Extract the cube root of 4088324799.

|                              |                 |                      |                                |   |
|------------------------------|-----------------|----------------------|--------------------------------|---|
|                              |                 |                      | 4088324799   1599. <i>Ans.</i> | <b>TO EXTRACT ANY<br/>ROOT WHATEVER.</b><br><br>If $N$ be any given number whatever whose root is sought, $n$ the index of the power, $r$ the nearest rational root; or $r^m$ the nearest rational power to $N$ , whether greater or less, and $R$ = the root sought: then— |
| True divisor $1^3$           | =               | 1                    | 1                              |   |
| Trial divisor $1^2 \times 3$ | =               | 3                    | 3088                           |   |
|                              |                 | $35 \times 5 = 175$  |                                |   |
| True divisor                 |                 | $475 \times 5$       | 2375                           |   |
|                              | $5^2$           | = 25                 | 713324                         |   |
| Trial divisor                |                 | 675                  |                                |   |
|                              | $459 \times 9$  | = 4131               |                                |   |
|                              |                 | $71631 \times 9$     | 644679                         |   |
|                              | $9^2$           | = 81                 | 68645799                       |   |
| Trial divisor                |                 | = 75843              |                                |   |
|                              | $4779 \times 9$ | = 43011              |                                |   |
| True divisor                 |                 | = $7627311 \times 9$ | 68645799                       |   |

$$R = \frac{\{N \times (n+1)\} + \{(n-1) \times r^m\}}{\{N \times (n-1)\} + \{(n+1) \times r^m\}} \times r.$$

TABLE OF THE WEIGHT AND STRENGTH OF MATERIALS.

## METALS.

| Name               | Specific Gravity | Lbs. in a Cub. Foot | Tearing Force   | Crushing Force  | Modulus of Elasticity |
|--------------------|------------------|---------------------|-----------------|-----------------|-----------------------|
|                    |                  |                     | Lbs. on Sq. In. | Lbs. on Sq. In. | Lbs. on Sq. In.       |
| Aluminum, cast .   | 2.560            | 160.0               | —               | —               | —                     |
| „ sheet .          | 2.670            | 166.9               | —               | —               | —                     |
| Antimony, cast .   | 6.702            | 418.9               | 1,053           | —               | —                     |
| Arsenic .          | 5.763            | 360.2               | —               | —               | —                     |
| Bismuth, cast .    | 9.822            | 613.9               | 2,798           | —               | —                     |
| Brass, cast .      | 8.396            | 524.8               | 18,000          | 10,300          | 9,170,000             |
| „ sheet .          | 8.525            | 532.8               | 31,360          | —               | —                     |
| „ wire .           | 8.544            | 533.0               | 49,000          | —               | 14,230,000            |
| Bronze .           | 8.222            | 513.4               | —               | —               | —                     |
| Cobalt, cast .     | 7.811            | 488.2               | —               | —               | —                     |
| Copper, bolts .    | 8.850            | 531.3               | 36,000          | —               | —                     |
| „ cast .           | 8.607            | 537.9               | 19,000          | —               | —                     |
| „ sheet .          | 8.785            | 549.1               | 30,000          | —               | —                     |
| „ wire .           | 8.878            | 548.6               | 60,000          | —               | —                     |
| Gold, pure .       | 19.258           | 1203.6              | 20,400          | —               | —                     |
| „ hammered .       | 19.362           | 1210.1              | —               | —               | —                     |
| „ standard .       | 17.647           | 1102.9              | —               | —               | —                     |
| Gun metal .        | 8.153            | 509.6               | 36,000          | —               | 9,873,000             |
| Iron, cast, from . | 6.955            | 434.7               | 13,400          | 82,000          | 14,000,000            |
| „ „ to .           | 7.295            | 455.9               | 29,000          | 145,000         | 22,900,000            |
| „ „ average .      | 7.125            | 445.3               | 16,500          | 112,000         | 17,000,000            |
| „ wrought, from .  | 7.560            | 472.5               | 50,000          | 40,300          | —                     |
| „ „ to .           | 7.800            | 487.5               | 63,000          | 32,000          | —                     |
| „ „ average .      | 7.680            | 480.0               | 60,000          | 36,000          | 28,000,000            |
| Lead, cast .       | 11.352           | 709.5               | 1,792           | 6,900           | —                     |
| „ sheet .          | 11.400           | 712.8               | 3,328           | —               | 720,000               |
| Mercury, fluid .   | 13.568           | 848.0               | —               | —               | —                     |
| „ solid .          | 15.632           | 977.0               | —               | —               | —                     |
| Nickel, cast .     | 7.807            | 487.9               | —               | —               | —                     |
| Pewter .           | 11.600           | 7.25                | —               | —               | —                     |
| Platinum, pure .   | 19.500           | 1218.8              | —               | —               | —                     |
| „ sheet .          | 20.337           | 1271.0              | 265,000         | —               | 24,240,000            |
| Silver, pure .     | 10.474           | 654.6               | 42,000          | —               | —                     |
| „ standard .       | 10.534           | 658.4               | —               | —               | —                     |
| Steel, hard .      | 7.818            | 488.6               | 103,000         | —               | 42,000,000            |
| „ soft .           | 7.834            | 489.6               | 121,700         | —               | 29,000,000            |
| Tin, cast .        | 7.291            | 455.7               | 4,600           | 14,600          | 4,550,000             |
| Type metal .       | 10.450           | 653.1               | —               | —               | —                     |
| Zinc, cast .       | 7.028            | 439.3               | 8,500           | —               | 13,500,000            |
| „ sheet .          | 7.291            | 455.7               | 7,111           | —               | 12,850,000            |

TABLE OF THE WEIGHT AND STRENGTH OF MATERIALS (cont.)

| TIMBER.                      |                  |                     |                                  |                                   |                                   |  |
|------------------------------|------------------|---------------------|----------------------------------|-----------------------------------|-----------------------------------|--|
| Name                         | Specific Gravity | Lbs. in a Cub. Foot | Tearing Force<br>Lbs. on Sq. In. | Crushing Force<br>Lbs. on Sq. In. | Breaking Force<br>Lbs. on Sq. In. | Modulus of Elasticity<br>Lbs. on Sq. In. |
| Acacia . . . . .             | .710             | 44.4                | 16,000                           | —                                 | —                                 | —  |
| Alder . . . . .              | .555             | 34.6                | 14,186                           | 6,895                             | 9,540                             | 1,087,000                                |
| Apple . . . . .              | .793             | 49.5                | 19,500                           | 6,499                             | —                                 | —  |
| Ash . . . . .                | .753             | 47.0                | 17,000                           | 9,000                             | 12,200                            | 1,645,000                                |
| Beech . . . . .              | .700             | 43.8                | 11,500                           | 9,363                             | 9,336                             | 1,354,000                                |
| Birch . . . . .              | .750             | 46.9                | 15,000                           | 6,402                             | 11,671                            | 1,646,000                                |
| Box . . . . .                | 1.000            | 62.5                | 20,000                           | 10,299                            | —                                 | —  |
| Cedar . . . . .              | .486             | 30.8                | 11,400                           | 5,860                             | 7,420                             | 486,000                                  |
| Chestnut . . . . .           | .535             | 33.4                | 13,300                           | —                                 | 10,656                            | 1,137,000                                |
| Cypress . . . . .            | .855             | 41.0                | 6,000                            | —                                 | —                                 | —  |
| Ebony . . . . .              | 1.279            | 79.4                | —                                | 19,000                            | 13,000                            | 1,360,000                                |
| Elder . . . . .              | .696             | 43.4                | 10,230                           | 8,467                             | —                                 | —  |
| Elm . . . . .                | .544             | 33.8                | 13,489                           | 10,331                            | 6,078                             | 700,000                                  |
| Fir, red pine . . . . .      | .577             | 36.1                | 14,300                           | 5,375                             | 8,844                             | 1,458,000                                |
| „ pitch pine . . . . .       | .660             | 41.2                | 7,818                            | —                                 | 9,792                             | 1,226,000                                |
| „ spruce . . . . .           | .512             | 32.0                | 10,100                           | 6,500                             | 12,346                            | 1,804,000                                |
| „ yellow pine . . . . .      | .461             | 28.8                | —                                | 5,445                             | —                                 | 1,600,000                                |
| „ larch . . . . .            | .496             | 31.0                | 10,220                           | 5,568                             | 5,943                             | 1,363,000                                |
| Greenheart . . . . .         | 1.001            | 62.5                | —                                | —                                 | 16,554                            | 2,656,000                                |
| Hawthorn . . . . .           | .910             | 56.8                | 10,500                           | —                                 | —                                 | —  |
| Hazel . . . . .              | .860             | 53.7                | 18,000                           | 4,600                             | —                                 | —  |
| Hornbeam . . . . .           | .760             | 47.4                | 20,240                           | 7,289                             | —                                 | —  |
| Laburnum . . . . .           | .920             | 57.4                | 10,500                           | —                                 | —                                 | —  |
| Lancewood . . . . .          | .675             | 42.1                | —                                | 6,614                             | 17,354                            | 812,000                                  |
| Lignum-vitæ . . . . .        | 1.333            | 89.2                | 11,800                           | 9,921                             | 11,400                            | 558,000                                  |
| Lime . . . . .               | .760             | 47.4                | 23,600                           | —                                 | 11,202                            | 1,162,000                                |
| Mahogany, Honduras . . . . . | .560             | 35.0                | —                                | —                                 | 11,475                            | 1,593,000                                |
| „ Spanish . . . . .          | .853             | 53.2                | 21,800                           | 8,198                             | 7,560                             | 1,255,000                                |
| „ Australian . . . . .       | .952             | 59.4                | —                                | 9,921                             | 20,238                            | 1,157,000                                |
| Oak, British . . . . .       | .934             | 58.3                | 10,000                           | 10,055                            | 10,032                            | 1,451,000                                |
| „ Riga . . . . .             | .688             | 43.0                | 14,000                           | —                                 | 12,888                            | 1,610,000                                |
| „ Danzic . . . . .           | .756             | 47.2                | 12,780                           | 7,723                             | 8,742                             | 1,191,000                                |
| „ red . . . . .              | .872             | 54.4                | 10,253                           | 5,987                             | 10,596                            | 2,149,000                                |
| Poplar . . . . .             | .511             | 31.9                | 7,200                            | 5,124                             | 10,260                            | 1,184,000                                |
| Sycamore . . . . .           | .590             | 36.8                | 13,000                           | —                                 | 9,630                             | 1,036,000                                |
| Teak, Indian . . . . .       | .880             | 55.0                | 15,000                           | —                                 | 14,600                            | 2,800,000                                |
| „ African . . . . .          | .983             | 61.3                | 21,000                           | 9,320                             | 14,976                            | 2,305,000                                |
| Walnut . . . . .             | .671             | 41.8                | 8,130                            | 6,645                             | 8,000                             | —  |
| Willow . . . . .             | .408             | 25.3                | —                                | —                                 | 6,570                             | —  |
| Yew . . . . .                | .807             | 50.3                | 8,000                            | —                                 | —                                 | —  |

TABLE OF THE WEIGHT AND STRENGTH OF MATERIALS  
(concluded).

## MISCELLANEOUS SUBSTANCES.

| Name                       | Specific Gravity | Weight of a Cub. Foot, Lbs. | Crushing Force, Lbs. on Sq. In. | Name                       | Specific Gravity | Weight of a Cub. Foot, Lbs. | Crushing Force, Lbs. on Sq. In. |
|----------------------------|------------------|-----------------------------|---------------------------------|----------------------------|------------------|-----------------------------|---------------------------------|
| Asphalte . . . . .         | 2.50             | 156                         | —                               | Peat, hard . . . . .       | 1.83             | 88                          | —                               |
| Alabaster . . . . .        | 1.87             | 117                         | —                               | Plumbago . . . . .         | 2.27             | 139                         | —                               |
| Basalt . . . . .           | 2.72             | 170                         | 16,800                          | Porcelain, China . . . . . | 2.08             | 149                         | —                               |
| Brick, common . . . . .    | 2.00             | 125                         | —                               | Portland stone . . . . .   | 2.57             | 161                         | 6,856                           |
| " red . . . . .            | 2.16             | 134                         | 808                             | Pumice stone . . . . .     | .914             | 57                          | —                               |
| " Welsh fire . . . . .     | 2.40             | 150                         | —                               | Purbeck stone . . . . .    | 2.60             | 163                         | 9,160                           |
| Cement, Portland . . . . . | 1.30             | 84                          | 4,984                           | Rag stone . . . . .        | 2.47             | 154                         | —                               |
| Chalk . . . . .            | 2.77             | 173                         | 505                             | Rotten stone . . . . .     | 1.98             | 124                         | —                               |
| Coal . . . . .             | 1.27             | 79.4                        | —                               | Salt . . . . .             | 2.18             | 138                         | —                               |
| Coke . . . . .             | .744             | 46                          | —                               | Sand, fine pit . . . . .   | 1.52             | 95                          | —                               |
| Freestone . . . . .        | 2.45             | 153                         | 6,842                           | " coarse pit . . . . .     | 1.61             | 100                         | —                               |
| Gypsum . . . . .           | 2.17             | 135                         | —                               | " river . . . . .          | 1.88             | 117                         | —                               |
| Granite . . . . .          | 2.70             | 169                         | 12,800                          | Slate . . . . .            | 2.62             | 164                         | 15,000                          |
| Grindstone . . . . .       | 2.14             | 134                         | —                               | Sugar . . . . .            | 1.61             | 100                         | —                               |
| India rubber . . . . .     | .934             | 58.4                        | —                               | Sulphate of soda . . . . . | 2.20             | 137                         | —                               |
| Lime, quick . . . . .      | .848             | 53                          | —                               | Sulphur, native . . . . .  | 2.03             | 127                         | —                               |
| Limestone . . . . .        | 2.95             | 184                         | 9,160                           | " fused . . . . .          | 1.99             | 124                         | —                               |
| Marble . . . . .           | 2.72             | 170                         | 9,219                           | Tallow . . . . .           | .94              | 59                          | —                               |
| Mica . . . . .             | 2.79             | 173                         | —                               | Tar . . . . .              | 1.02             | 63                          | —                               |
| Mortar . . . . .           | 2.48             | 155                         | —                               | Tile, common . . . . .     | 1.83             | 113                         | —                               |

## LIQUIDS.

| Name                     | Specific Gravity | Weight of a Cub. Foot, Lbs. | Weight of a Cubic Inch, Lbs. | Name                      | Specific Gravity | Weight of a Cub. Foot, Lbs. | Weight of a Cubic Inch, Lbs. |
|--------------------------|------------------|-----------------------------|------------------------------|---------------------------|------------------|-----------------------------|------------------------------|
| Acetic acid . . . . .    | 1.06             | 66.4                        | .615                         | Oil of olives . . . . .   | .915             | 57.2                        | .530                         |
| Alcohol, proof . . . . . | .918             | 57                          | .538                         | " turpentine . . . . .    | .870             | 54.9                        | .508                         |
| Ether, acetic . . . . .  | .866             | 54                          | .501                         | " whale . . . . .         | .928             | 57.7                        | .534                         |
| " muriatic . . . . .     | .730             | 45.6                        | .422                         | Oils, average . . . . .   | .880             | 55.0                        | .510                         |
| " sulphuric . . . . .    | .740             | 46.3                        | .428                         | Petroleum . . . . .       | .878             | 54.8                        | .508                         |
| Muriatic acid . . . . .  | 1.20             | 75                          | .694                         | Sulphuric acid . . . . .  | 1.84             | 115                         | .066                         |
| Nitric acid . . . . .    | 1.27             | 79.4                        | .736                         | Vinegar . . . . .         | 1.01             | 63.1                        | .585                         |
| Oil of aniseed . . . . . | .987             | 61.6                        | .570                         | Water, rain . . . . .     | 1.00             | 62.5                        | .579                         |
| " caraway seed . . . . . | .905             | 56.6                        | .524                         | " sea . . . . .           | 1.03             | 64.4                        | .595                         |
| " hempseed . . . . .     | .926             | 57.8                        | .538                         | Wine, champagne . . . . . | .998             | 62.4                        | .578                         |
| " lavender . . . . .     | .894             | 55.9                        | .517                         | " burgundy . . . . .      | .991             | 62.0                        | .573                         |
| " linseed . . . . .      | .940             | 58.8                        | .544                         | " madeira . . . . .       | 1.04             | 65.0                        | .601                         |
| " rapeseed . . . . .     | .918             | 57.0                        | .528                         | " port . . . . .          | .997             | 62.3                        | .577                         |

## ESTIMATION OF QUANTITIES.

Tons  $\times$  2240 = lbs. Tons  $\times$  20 = cwts. Lbs.  $\times$  .000446428 = tons.

*Weight of Round or Elliptical Bars.*

Diameter  $\times$  diameter  $\times$  length in feet  $\times$  constant = weight in lbs.

*Weight of Square or Rectangular Bars.*

Width  $\times$  thickness  $\times$  length in feet  $\times$  constant = weight in lbs.

*Weight of Plating or Planking.*

Thickness  $\times$  breadth in feet  $\times$  length in feet  $\times$  constant = weight in lbs.

## VALUES OF CONSTANTS FOR ROUND OR ELLIPTICAL BARS.

| Material                 | Diameters taken in |                   |                   |                   |                   |                   |
|--------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                          | Ins.               | $\frac{1}{2}$ In. | $\frac{3}{4}$ In. | $\frac{1}{2}$ In. | $\frac{3}{8}$ In. | $\frac{1}{4}$ In. |
| Brass, sheet . . .       | 2.905980           | .726495           | .181624           | .045406           | .011351           | .002838           |
| Iron, wrought . . .      | 2.61800            | .654500           | .163625           | .040908           | .010227           | .002557           |
| Lead, sheet . . .        | 3.88773            | .971933           | .242983           | .060746           | .015186           | .003797           |
| Steel, soft . . .        | 2.67036            | .667590           | .166898           | .041724           | .010431           | .002608           |
| Elm, American . . .      | .261800            | .065450           | .016363           | .004091           | .001023           | .000256           |
| Mahogany, Honduras . . . | .196350            | .049088           | .012272           | .003068           | .000767           | .000192           |
| " Spanish . . .          | .287980            | .071995           | .017999           | .004500           | .001125           | .000281           |
| Oak, Dantzic . . .       | .261800            | .065450           | .016363           | .004091           | .001023           | .000356           |
| " English . . .          | .307615            | .076904           | .019228           | .004807           | .001202           | .000300           |
| Pine, red . . .          | .196350            | .049088           | .012272           | .003068           | .000767           | .000192           |
| " yellow . . .           | .157080            | .039270           | .009818           | .002454           | .000614           | .000153           |
| Teak, Indian . . .       | .287980            | .071995           | .017999           | .004500           | .001125           | .000281           |

## VALUES OF CONSTANTS FOR SQUARE OR RECTANGULAR BARS.

| Material                 | Width and Thickness taken in |                   |                   |                   |                   |                    |
|--------------------------|------------------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
|                          | Ins.                         | $\frac{1}{2}$ In. | $\frac{3}{4}$ In. | $\frac{1}{2}$ In. | $\frac{1}{8}$ In. | $\frac{1}{16}$ In. |
| Brass, sheet . . .       | 3.70000                      | .925000           | .231250           | .057813           | .014453           | .003618            |
| Iron, wrought . . .      | 3.33333                      | .833333           | .208333           | .052083           | .013021           | .003255            |
| Lead, sheet . . .        | 4.95000                      | 1.23750           | .309375           | .077344           | .019336           | .004834            |
| Steel, soft . . .        | 3.40000                      | .850000           | .212500           | .053125           | .013281           | .003320            |
| Elm, American . . .      | .333333                      | .083333           | .020833           | .005208           | .001302           | .000326            |
| Mahogany, Honduras . . . | .250000                      | .062500           | .015625           | .003906           | .000977           | .000244            |
| " Spanish . . .          | .366667                      | .091667           | .022917           | .005729           | .001432           | .000358            |
| Oak, Dantzic . . .       | .333333                      | .083333           | .020833           | .005208           | .001202           | .000326            |
| " English . . .          | .391667                      | .097917           | .024479           | .006120           | .001530           | .000382            |
| Pine, red . . .          | .250000                      | .062500           | .015625           | .003906           | .000977           | .000244            |
| " yellow . . .           | .200000                      | .050000           | .012500           | .003125           | .000781           | .000195            |
| Teak, Indian . . .       | .366667                      | .091667           | .022917           | .005729           | .001432           | .000358            |

## VALUES OF CONSTANTS FOR PLATING OR PLANKING.

| Material                 | Thickness taken in |                   |                   |                   |                   |                    |                   |
|--------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|--------------------|-------------------|
|                          | Ins.               | $\frac{1}{2}$ In. | $\frac{3}{4}$ In. | $\frac{1}{2}$ In. | $\frac{1}{8}$ In. | $\frac{3}{16}$ In. | $\frac{1}{4}$ In. |
| Brass, sheet . . .       | 44.4               | 22.2              | 11.100            | 5.550             | 2.7750            | 1.88750            | .69375            |
| Iron, wrought . . .      | 40.0               | 20.0              | 10.000            | 5.000             | 2.5000            | 1.25000            | .62500            |
| Lead, sheet . . .        | 59.4               | 29.7              | 14.85             | 7.425             | 3.7125            | 1.85625            | .92818            |
| Steel, soft . . .        | 40.8               | 20.4              | 10.20             | 5.100             | 2.5500            | 1.27500            | .63750            |
| Elm, American . . .      | 4.00               | 2.00              | 1.000             | .5000             | .25000            | .12500             | .62500            |
| Mahogany, Honduras . . . | 3.00               | 1.50              | .750              | .3750             | .18750            | .09375             | .04688            |
| " Spanish . . .          | 4.40               | 2.20              | 1.100             | .5500             | .27500            | .13750             | .06875            |
| Oak, Dantzic . . .       | 4.00               | 2.00              | 1.000             | .5000             | .25000            | .125000            | .06250            |
| " English . . .          | 4.70               | 2.35              | 1.175             | .5875             | .29375            | .14688             | .07344            |
| Pine, red . . .          | 3.00               | 1.50              | .750              | .3750             | .18750            | .09375             | .04688            |
| " yellow . . .           | 2.40               | 1.20              | .600              | .3000             | .15000            | .07500             | .03750            |
| Teak, Indian . . .       | 4.40               | 2.20              | 1.100             | .5500             | .27500            | .13750             | .06875            |

### WEIGHT OF PIPES.

$W$  = weight per lineal foot in lbs.       $D$  = outside diameter in ins.  
 $K$  = constant from below.       $d$  = inside      "      "

$$W = (D^2 - d^2)K.$$

#### Values of $K$ for Pipes.

|                  |                      |                 |
|------------------|----------------------|-----------------|
| Brass = 2.9060.  | Iron, cast = 2.4282. | Lead = 3.8877.  |
| Copper = 2.9943. | " wrought = 2.6180.  | Steel = 2.6704. |

### WEIGHT OF ANGLE IRON.

$W$  = weight in lbs. per lineal foot.       $S$  = sum of the widths of flanges in ins.  
 $T$  = thickness of flanges in ins.  

$$W = T(S - T) 3.83333.$$

### RELATIVE WEIGHTS OF DIFFERENT SUBSTANCES.

Wrought iron = 1.

|                        |                             |                        |
|------------------------|-----------------------------|------------------------|
| Brass, sheet = 1.1100. | Beech = .0896.              | Oak, English = .1175.  |
| Copper, " = 1.1438.    | Elm = .1000.                | Pine, red = .0750.     |
| Iron, cast = .9275.    | Fir, spruce = .0833.        | " yellow = .0600.      |
| Lead, sheet = 1.4850.  | Mahogany, Honduras = .0750. | Sycamore = .0808.      |
| Steel, soft = 1.0200.  | " Spanish = .1100.          | Teak, African = .0508. |
| Tin = .9500.           | Maple = .1021.              | " Indian = .1100.      |
| Zinc = .9494.          | Oak, Dantzic = .0100.       | Willow = .0521.        |

### WEIGHT, &c., OF FRESH WATER.

A cubic foot = .0279 ton = 62.39 lbs. = 998.18 avd. ozs. = 6.2321 galls.  
A cubic inch = .0361 lb. = .5776 avd. oz. = .0336 gall.  
A gallon = .0045 ton = 10.000 lbs. = 160.15 avd. ozs. = .1315 cu. ft.  
A ton = 35.905 cu. ft. = 2240 lbs. = 228.76 galls.  
Weight of fresh water = weight of salt water  $\times$  .9740.

### WEIGHT, &c., OF SALT WATER.

A cubic foot = .0286 ton = 64.05 lbs. = 1024.80 avd. ozs. = 6.2321 galls.  
A cubic inch = .0371 lb. = .5930 avd. oz. = .0036 gall.  
A gallon = .0046 ton = 10.276 lbs. = 164.41 avd. ozs. = .1315 cu. ft.  
A ton = 34.973 cu. ft. = 2240 lbs. = 217.95 galls.

*Note.*—A cubic foot of salt water is usually taken at 35 cu. ft. to the ton and 64 lbs. to the cubic foot, fresh water being taken at 36 cu. ft. to the ton and 62.25 lbs. to the cubic foot.

### MISCELLANEOUS FACTORS.

|  |   |
|--|---|
| A ton = 1.01605 tonne or tonneau.      | A tonne or tonneau = .984206 ton.       |
| An avd. lb. = .45359 kilogram.         | A kilogram = 2.20462 lbs.               |
| A foot = .304797 metre.                | A metre = 3.2808693 feet.               |
| A sq. foot = .092901 sq. metre.        | A sq. metre = 10.7641 sq. feet.         |
| A sq. inch = 6.45148 sq. milli-metres. | A sq. millimetre = .00155003 sq. in.    |
| A cu. ft. = .028316 cu. metre.         | A cubic metre = 35.3156 cu. feet.       |
| A cubic yard = .764534 cu. metre.      | " " = 1.30799 cu. yd.                   |
| A mile = 1.60933 kilometre.            | A kilometre = .621377 mile.             |
| Knot per hour = 1.688 foot per second. | Foot per second = .592 knot per hour.   |
| " " = .5144 metre per second.          | Metre per second = 1.944 knot per hour. |
| Mile per hour = 1.467 foot per second. | Foot per second = .682 mile per hour.   |
| A gallon = 4.54102 litres.             | A litre = .22016 gallons.               |







TABLE OF THE WEIGHT OF MALLEABLE FLAT IRON IN LBS. PER LINEAL FOOT.

| Thickness in Fractions of an Inch |               |                |               |                |               |                |               |                |               |                 |               |                 |               |                 |       | Breadth of Plate (ins.) |
|-----------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|-------|-------------------------|
| $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 in. | Breadth of Plate (ins.) |
| 1                                 | .21           | .42            | .63           | 1.04           | 1.25          | 1.46           | 1.67          | 1.88           | 2.08          | 2.29            | 2.50          | 2.71            | 2.92          | 3.13            | 3.33  | 1                       |
| 1 1/4                             | .26           | .52            | .78           | 1.30           | 1.56          | 1.82           | 2.08          | 2.34           | 2.60          | 2.86            | 3.13          | 3.39            | 3.65          | 3.91            | 4.16  | 1 1/4                   |
| 1 1/2                             | .31           | .63            | .94           | 1.56           | 1.88          | 2.19           | 2.50          | 2.81           | 3.13          | 3.44            | 3.75          | 4.06            | 4.38          | 4.69            | 5.00  | 1 1/2                   |
| 1 3/4                             | .36           | .73            | 1.09          | 1.82           | 2.19          | 2.55           | 2.92          | 3.28           | 3.65          | 4.01            | 4.38          | 4.74            | 5.10          | 5.47            | 5.83  | 1 3/4                   |
| 2                                 | .42           | .83            | 1.25          | 2.08           | 2.50          | 2.92           | 3.33          | 3.75           | 4.17          | 4.58            | 5.00          | 5.42            | 5.83          | 6.25            | 6.67  | 2                       |
| 2 1/4                             | .47           | .94            | 1.41          | 2.34           | 2.81          | 3.28           | 3.75          | 4.22           | 4.69          | 5.16            | 5.63          | 6.09            | 6.56          | 7.03            | 7.50  | 2 1/4                   |
| 2 1/2                             | .52           | 1.04           | 1.56          | 2.60           | 3.13          | 3.65           | 4.17          | 4.69           | 5.21          | 5.73            | 6.25          | 6.77            | 7.29          | 7.81            | 8.33  | 2 1/2                   |
| 2 3/4                             | .57           | 1.15           | 1.72          | 2.86           | 3.44          | 4.01           | 4.58          | 5.16           | 5.73          | 6.30            | 6.88          | 7.45            | 8.02          | 8.59            | 9.17  | 2 3/4                   |
| 3                                 | .63           | 1.25           | 1.88          | 3.13           | 3.75          | 4.38           | 5.00          | 5.63           | 6.25          | 6.88            | 7.50          | 8.13            | 8.75          | 9.38            | 10.00 | 3                       |
| 3 1/4                             | .68           | 1.35           | 2.03          | 3.39           | 4.06          | 4.74           | 5.42          | 6.09           | 6.77          | 7.45            | 8.13          | 8.80            | 9.48          | 10.16           | 10.83 | 3 1/4                   |
| 3 1/2                             | .73           | 1.46           | 2.19          | 3.65           | 4.38          | 5.10           | 5.83          | 6.56           | 7.29          | 8.02            | 8.75          | 9.48            | 10.21         | 10.94           | 11.67 | 3 1/2                   |
| 3 3/4                             | .78           | 1.56           | 2.34          | 3.91           | 4.69          | 5.47           | 6.25          | 7.03           | 7.81          | 8.59            | 9.38          | 10.16           | 10.94         | 11.72           | 12.50 | 3 3/4                   |
| 4                                 | .83           | 1.67           | 2.50          | 4.17           | 5.00          | 5.83           | 6.67          | 7.50           | 8.33          | 9.17            | 10.00         | 10.83           | 11.67         | 12.50           | 13.33 | 4                       |
| 4 1/4                             | .89           | 1.77           | 2.66          | 4.43           | 5.31          | 6.20           | 7.08          | 7.97           | 8.85          | 9.74            | 10.63         | 11.51           | 12.40         | 13.28           | 14.17 | 4 1/4                   |
| 4 1/2                             | .94           | 1.88           | 2.81          | 4.69           | 5.63          | 6.56           | 7.50          | 8.44           | 9.38          | 10.31           | 11.25         | 12.19           | 13.13         | 14.06           | 15.00 | 4 1/2                   |
| 4 3/4                             | .99           | 1.98           | 2.97          | 4.95           | 5.94          | 6.93           | 7.92          | 8.91           | 9.90          | 10.89           | 11.88         | 12.86           | 13.85         | 14.84           | 15.83 | 4 3/4                   |
| 5                                 | 1.04          | 2.08           | 3.13          | 5.21           | 6.25          | 7.29           | 8.33          | 9.38           | 10.42         | 11.46           | 12.50         | 13.54           | 14.58         | 15.63           | 16.67 | 5                       |
| 5 1/4                             | 1.09          | 2.19           | 3.28          | 5.47           | 6.56          | 7.66           | 8.75          | 9.84           | 10.94         | 12.03           | 13.13         | 14.22           | 15.31         | 16.41           | 17.50 | 5 1/4                   |
| 5 1/2                             | 1.15          | 2.29           | 3.44          | 5.73           | 6.88          | 8.02           | 9.17          | 10.31          | 11.46         | 12.60           | 13.75         | 14.90           | 16.04         | 17.19           | 18.33 | 5 1/2                   |
| 5 3/4                             | 1.20          | 2.40           | 3.59          | 5.99           | 7.19          | 8.39           | 9.58          | 10.78          | 11.98         | 13.18           | 14.38         | 15.57           | 16.77         | 17.97           | 19.17 | 5 3/4                   |
| 6                                 | 1.25          | 2.50           | 3.75          | 6.25           | 7.50          | 8.75           | 10.00         | 11.25          | 12.50         | 13.75           | 15.00         | 16.25           | 17.50         | 18.75           | 20.00 | 6                       |

| Thickness in Fractions of an Inch |               |                |               |                |               |                |               |                |               |                 |               |                 |               |                 |       | Breadth of Plate (ins.) |
|-----------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|-------|-------------------------|
| $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 in. | Breadth of Plate (ins.) |
| 1                                 | .21           | .42            | .63           | 1.04           | 1.25          | 1.46           | 1.67          | 1.88           | 2.08          | 2.29            | 2.50          | 2.71            | 2.92          | 3.13            | 3.33  | 1                       |
| 1 1/4                             | .26           | .52            | .78           | 1.30           | 1.56          | 1.82           | 2.08          | 2.34           | 2.60          | 2.86            | 3.13          | 3.39            | 3.65          | 3.91            | 4.16  | 1 1/4                   |
| 1 1/2                             | .31           | .63            | .94           | 1.56           | 1.88          | 2.19           | 2.50          | 2.81           | 3.13          | 3.44            | 3.75          | 4.06            | 4.38          | 4.69            | 5.00  | 1 1/2                   |
| 1 3/4                             | .36           | .73            | 1.09          | 1.82           | 2.19          | 2.55           | 2.92          | 3.28           | 3.65          | 4.01            | 4.38          | 4.74            | 5.10          | 5.47            | 5.83  | 1 3/4                   |
| 2                                 | .42           | .83            | 1.25          | 2.08           | 2.50          | 2.92           | 3.33          | 3.75           | 4.17          | 4.58            | 5.00          | 5.42            | 5.83          | 6.25            | 6.67  | 2                       |
| 2 1/4                             | .47           | .94            | 1.41          | 2.34           | 2.81          | 3.28           | 3.75          | 4.22           | 4.69          | 5.16            | 5.63          | 6.09            | 6.56          | 7.03            | 7.50  | 2 1/4                   |
| 2 1/2                             | .52           | 1.04           | 1.56          | 2.60           | 3.13          | 3.65           | 4.17          | 4.69           | 5.21          | 5.73            | 6.25          | 6.77            | 7.29          | 7.81            | 8.33  | 2 1/2                   |
| 2 3/4                             | .57           | 1.15           | 1.72          | 2.86           | 3.44          | 4.01           | 4.58          | 5.16           | 5.73          | 6.30            | 6.88          | 7.45            | 8.02          | 8.59            | 9.17  | 2 3/4                   |
| 3                                 | .63           | 1.25           | 1.88          | 3.13           | 3.75          | 4.38           | 5.00          | 5.63           | 6.25          | 6.88            | 7.50          | 8.13            | 8.75          | 9.38            | 10.00 | 3                       |
| 3 1/4                             | .68           | 1.35           | 2.03          | 3.39           | 4.06          | 4.74           | 5.42          | 6.09           | 6.77          | 7.45            | 8.13          | 8.80            | 9.48          | 10.16           | 10.83 | 3 1/4                   |
| 3 1/2                             | .73           | 1.46           | 2.19          | 3.65           | 4.38          | 5.10           | 5.83          | 6.56           | 7.29          | 8.02            | 8.75          | 9.48            | 10.21         | 10.94           | 11.67 | 3 1/2                   |
| 3 3/4                             | .78           | 1.56           | 2.34          | 3.91           | 4.69          | 5.47           | 6.25          | 7.03           | 7.81          | 8.59            | 9.38          | 10.16           | 10.94         | 11.72           | 12.50 | 3 3/4                   |
| 4                                 | .83           | 1.67           | 2.50          | 4.17           | 5.00          | 5.83           | 6.67          | 7.50           | 8.33          | 9.17            | 10.00         | 10.83           | 11.67         | 12.50           | 13.33 | 4                       |
| 4 1/4                             | .89           | 1.77           | 2.66          | 4.43           | 5.31          | 6.20           | 7.08          | 7.97           | 8.85          | 9.74            | 10.63         | 11.51           | 12.40         | 13.28           | 14.17 | 4 1/4                   |
| 4 1/2                             | .94           | 1.88           | 2.81          | 4.69           | 5.63          | 6.56           | 7.50          | 8.44           | 9.38          | 10.31           | 11.25         | 12.19           | 13.13         | 14.06           | 15.00 | 4 1/2                   |
| 4 3/4                             | .99           | 1.98           | 2.97          | 4.95           | 5.94          | 6.93           | 7.92          | 8.91           | 9.90          | 10.89           | 11.88         | 12.86           | 13.85         | 14.84           | 15.83 | 4 3/4                   |
| 5                                 | 1.04          | 2.08           | 3.13          | 5.21           | 6.25          | 7.29           | 8.33          | 9.38           | 10.42         | 11.46           | 12.50         | 13.54           | 14.58         | 15.63           | 16.67 | 5                       |
| 5 1/4                             | 1.09          | 2.19           | 3.28          | 5.47           | 6.56          | 7.66           | 8.75          | 9.84           | 10.94         | 12.03           | 13.13         | 14.22           | 15.31         | 16.41           | 17.50 | 5 1/4                   |
| 5 1/2                             | 1.15          | 2.29           | 3.44          | 5.73           | 6.88          | 8.02           | 9.17          | 10.31          | 11.46         | 12.60           | 13.75         | 14.90           | 16.04         | 17.19           | 18.33 | 5 1/2                   |
| 5 3/4                             | 1.20          | 2.40           | 3.59          | 5.99           | 7.19          | 8.39           | 9.58          | 10.78          | 11.98         | 13.18           | 14.38         | 15.57           | 16.77         | 17.97           | 19.17 | 5 3/4                   |
| 6                                 | 1.25          | 2.50           | 3.75          | 6.25           | 7.50          | 8.75           | 10.00         | 11.25          | 12.50         | 13.75           | 15.00         | 16.25           | 17.50         | 18.75           | 20.00 | 6                       |

TABLE OF THE WEIGHT OF MALLEABLE FLAT IRON IN LBS. PER LINEAL FOOT (concluded).

| Breadth<br>of Plate<br>(ins.) | Thickness in Fractions of an Inch |                |               |                |               |                |               |                |               |                 |               |                 |               |                 |       | Breadth<br>of Plate<br>(ins.) |
|-------------------------------|-----------------------------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|-------|-------------------------------|
|                               | $\frac{1}{16}$                    | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 in. |                               |
| 6 $\frac{1}{4}$               | 1.30                              | 3.91           | 5.21          | 6.51           | 7.81          | 9.11           | 10.42         | 11.72          | 13.02         | 14.32           | 15.63         | 16.93           | 18.23         | 19.53           | 20.83 | 6 $\frac{1}{2}$               |
| 6 $\frac{3}{4}$               | 1.35                              | 4.06           | 5.42          | 6.77           | 8.13          | 9.48           | 10.83         | 12.19          | 13.54         | 14.90           | 16.25         | 17.60           | 18.96         | 20.31           | 21.67 | 6 $\frac{3}{4}$               |
| 6 $\frac{1}{2}$               | 1.41                              | 4.22           | 5.63          | 7.03           | 8.44          | 9.84           | 11.25         | 12.66          | 14.06         | 15.47           | 16.88         | 18.28           | 19.69         | 21.09           | 22.50 | 7                             |
| 7                             | 1.46                              | 4.38           | 5.83          | 7.29           | 8.75          | 10.21          | 11.67         | 13.13          | 14.58         | 16.04           | 17.50         | 18.96           | 20.42         | 21.88           | 23.33 | 7 $\frac{1}{4}$               |
| 7 $\frac{1}{4}$               | 1.51                              | 4.53           | 6.04          | 7.55           | 9.06          | 10.57          | 12.08         | 13.59          | 15.10         | 16.61           | 18.13         | 19.64           | 21.15         | 22.66           | 24.17 | 7 $\frac{1}{2}$               |
| 7 $\frac{1}{2}$               | 1.56                              | 4.69           | 6.25          | 7.81           | 9.38          | 10.94          | 12.50         | 14.06          | 15.63         | 17.19           | 18.75         | 20.31           | 21.88         | 23.44           | 25.00 | 7 $\frac{3}{4}$               |
| 7 $\frac{3}{4}$               | 1.61                              | 4.84           | 6.46          | 8.07           | 9.69          | 11.30          | 12.92         | 14.53          | 16.15         | 17.76           | 19.38         | 20.99           | 22.60         | 24.22           | 25.83 | 8                             |
| 8                             | 1.67                              | 5.00           | 6.61          | 8.33           | 10.00         | 11.67          | 13.33         | 15.00          | 16.67         | 18.33           | 20.00         | 21.67           | 23.33         | 25.00           | 26.67 | 8 $\frac{1}{4}$               |
| 8 $\frac{1}{4}$               | 1.72                              | 5.16           | 6.88          | 8.59           | 10.31         | 12.03          | 13.75         | 15.47          | 17.19         | 18.91           | 20.63         | 22.34           | 24.06         | 25.78           | 27.50 | 8 $\frac{1}{2}$               |
| 8 $\frac{1}{2}$               | 1.77                              | 5.31           | 7.08          | 8.85           | 10.63         | 12.40          | 14.17         | 15.94          | 17.71         | 19.48           | 21.25         | 23.02           | 24.79         | 26.56           | 28.33 | 8 $\frac{3}{4}$               |
| 8 $\frac{3}{4}$               | 1.82                              | 5.47           | 7.29          | 9.11           | 10.94         | 12.76          | 14.58         | 16.41          | 18.23         | 20.05           | 21.88         | 23.70           | 25.52         | 27.34           | 29.17 | 9                             |
| 9                             | 1.88                              | 5.63           | 7.50          | 9.38           | 11.25         | 13.13          | 15.00         | 16.88          | 18.75         | 20.63           | 22.50         | 24.38           | 26.25         | 28.13           | 30.00 | 9 $\frac{1}{4}$               |
| 9 $\frac{1}{4}$               | 1.93                              | 5.78           | 7.71          | 9.64           | 11.56         | 13.49          | 15.42         | 17.34          | 19.27         | 21.20           | 23.13         | 25.05           | 26.98         | 28.91           | 30.83 | 9 $\frac{1}{2}$               |
| 9 $\frac{1}{2}$               | 1.98                              | 5.94           | 7.92          | 9.90           | 11.88         | 13.85          | 15.83         | 17.81          | 19.79         | 21.77           | 23.75         | 25.73           | 27.71         | 29.69           | 31.67 | 9 $\frac{3}{4}$               |
| 9 $\frac{3}{4}$               | 2.03                              | 6.09           | 8.13          | 10.16          | 12.19         | 14.22          | 16.25         | 18.28          | 20.31         | 22.34           | 24.38         | 26.41           | 28.44         | 30.47           | 32.50 | 10                            |
| 10                            | 2.08                              | 6.25           | 8.33          | 10.42          | 12.50         | 14.58          | 16.67         | 18.75          | 20.83         | 22.92           | 25.00         | 27.08           | 29.17         | 31.25           | 33.33 | 10 $\frac{1}{4}$              |
| 10 $\frac{1}{4}$              | 2.14                              | 6.41           | 8.54          | 10.68          | 12.81         | 14.95          | 17.08         | 19.22          | 21.35         | 23.49           | 25.63         | 27.76           | 29.90         | 32.03           | 34.17 | 10 $\frac{1}{2}$              |
| 10 $\frac{1}{2}$              | 2.19                              | 6.56           | 8.75          | 10.94          | 13.13         | 15.31          | 17.50         | 19.69          | 21.88         | 24.06           | 26.25         | 28.44           | 30.63         | 32.81           | 35.00 | 10 $\frac{3}{4}$              |
| 11                            | 2.29                              | 6.88           | 9.17          | 11.46          | 13.75         | 16.04          | 18.33         | 20.63          | 22.92         | 25.21           | 27.50         | 29.79           | 32.08         | 34.38           | 36.67 | 11                            |
| 11 $\frac{1}{4}$              | 2.40                              | 7.19           | 9.58          | 11.98          | 14.38         | 16.77          | 19.17         | 21.56          | 23.96         | 26.35           | 28.75         | 31.15           | 33.54         | 35.94           | 38.33 | 11 $\frac{1}{2}$              |
| 11 $\frac{1}{2}$              | 2.50                              | 7.50           | 10.00         | 12.50          | 15.00         | 17.5           | 20.00         | 22.50          | 25.00         | 27.50           | 30.00         | 32.50           | 35.00         | 37.50           | 40.00 | 12                            |
| Breadth<br>of Plate<br>(ins.) | $\frac{1}{16}$                    | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 in. | Breadth<br>of Plate<br>(ins.) |

TABLE OF THE WEIGHT OF SHEET METALS OF VARIOUS THICKNESSES IN LBS. PER SQUARE FOOT.

| Kind of Metal                            | Thickness in 16ths of an Inch |               |                |               |                |               |                |               |                |               |                 |               |                 |
|--|-------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|
|  | $\frac{1}{16}$                | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ |
| Iron .                                   | 2.5                           | 5.0           | 7.5            | 10.0          | 12.5           | 15.0          | 17.5           | 20.0          | 22.5           | 25.0          | 27.5            | 30.0          | 32.5            |
| Steel .                                  | 2.55                          | 5.10          | 7.65           | 10.20         | 12.75          | 15.30         | 17.85          | 20.40         | 22.95          | 25.50         | 28.05           | 30.60         | 33.15           |
| Brass .                                  | 2.78                          | 5.50          | 8.33           | 11.10         | 13.88          | 16.65         | 19.43          | 22.20         | 24.98          | 27.75         | 30.53           | 33.30         | 36.08           |
| Copper .                                 | 2.86                          | 5.72          | 8.58           | 11.44         | 14.30          | 17.16         | 20.02          | 22.88         | 25.73          | 28.59         | 31.45           | 34.31         | 37.17           |
| Lead .                                   | 3.71                          | 7.42          | 11.13          | 14.84         | 18.55          | 22.27         | 25.98          | 29.69         | 33.40          | 37.11         | 40.82           | 44.53         | 48.24           |
| Zinc .                                   | 2.37                          | 4.75          | 7.12           | 9.49          | 11.87          | 14.24         | 16.61          | 18.99         | 21.36          | 23.73         | 26.11           | 28.48         | 30.85           |
| Thicknesses by the Birmingham Wire Gauge |                               |               |                |               |                |               |                |               |                |               |                 |               |                 |
| Kind of Metal                            | No. 1                         | No. 2         | No. 3          | No. 4         | No. 5          | No. 6         | No. 7          | No. 8         | No. 9          | No. 10        | No. 11          | No. 12        | No. 13          |
|  | No. 14                        | No. 15        | No. 16         | No. 17        | No. 18         | No. 19        | No. 20         | No. 21        | No. 22         | No. 23        | No. 24          | No. 25        | No. 26          |
| Iron .                                   | 12.00                         | 11.36         | 10.36          | 9.52          | 8.80           | 8.12          | 7.20           | 6.60          | 5.92           | 5.36          | 4.80            | 4.36          | 3.80            |
| Steel .                                  | 12.24                         | 11.59         | 10.57          | 9.71          | 8.98           | 8.28          | 7.34           | 6.73          | 6.04           | 5.47          | 4.90            | 4.44          | 3.88            |
| Brass .                                  | 13.32                         | 12.61         | 11.50          | 10.57         | 9.77           | 9.01          | 7.99           | 7.33          | 6.57           | 5.95          | 5.32            | 4.84          | 4.22            |
| Copper .                                 | 13.73                         | 12.99         | 11.85          | 10.89         | 10.07          | 9.29          | 8.24           | 7.55          | 6.77           | 6.13          | 5.49            | 4.99          | 4.35            |
| Lead .                                   | 17.81                         | 16.86         | 15.38          | 14.13         | 13.06          | 12.05         | 10.69          | 9.80          | 8.79           | 7.96          | 7.13            | 6.47          | 5.64            |
| Zinc .                                   | 11.39                         | 10.78         | 9.84           | 9.04          | 8.36           | 7.71          | 6.84           | 6.27          | 5.62           | 5.09          | 4.56            | 4.14          | 3.61            |
| Thicknesses by the Birmingham Wire Gauge |                               |               |                |               |                |               |                |               |                |               |                 |               |                 |
| Kind of Metal                            | No. 17                        | No. 18        | No. 19         | No. 20        | No. 21         | No. 22        | No. 23         | No. 24        | No. 25         | No. 26        | No. 27          | No. 28        | No. 29          |
|  | No. 30                        | No. 31        | No. 32         | No. 33        | No. 34         | No. 35        | No. 36         | No. 37        | No. 38         | No. 39        | No. 40          | No. 41        | No. 42          |
| Iron .                                   | 2.32                          | 1.96          | 1.68           | 1.40          | 1.28           | 1.12          | 1.00           | .88           | .80            | .72           | .64             | .56           | .52             |
| Steel .                                  | 2.37                          | 2.00          | 1.71           | 1.43          | 1.31           | 1.14          | 1.02           | .90           | .82            | .73           | .65             | .57           | .53             |
| Brass .                                  | 2.58                          | 2.18          | 1.86           | 1.55          | 1.42           | 1.24          | 1.11           | .98           | .89            | .80           | .71             | .62           | .58             |
| Copper .                                 | 2.65                          | 2.24          | 1.92           | 1.60          | 1.46           | 1.28          | 1.14           | 1.01          | .92            | .82           | .73             | .64           | .59             |
| Lead .                                   | 3.44                          | 2.91          | 2.49           | 2.08          | 1.90           | 1.66          | 1.48           | 1.31          | 1.19           | 1.07          | .95             | .83           | .77             |
| Zinc .                                   | 2.20                          | 1.86          | 1.59           | 1.33          | 1.22           | 1.06          | .95            | .84           | .76            | .68           | .61             | .53           | .49             |

TABLE OF THE WEIGHT OF ANGLE IRON IN LBS. PER LINEAL FOOT.

| Sum of Flanges (ins.) |                       | Thickness in Fractions of an Inch |               |                |               |                |               |                |               |                |               |                 |               |                 |               |                 | Sum of Flanges (ins.) |  |
|-----------------------|-----------------------|-----------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|---------------|-----------------|-----------------------|--|
| 1                     | 1                     | $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | Sum of Flanges (ins.) |  |
| 1                     | 1                     | .20                               | .37           | .51            | .63           | .72            | —             | —              | —             | —              | —             | —               | —             | —               | —             | —               | 1                     |  |
| 1                     | 1                     | .25                               | .47           | .66            | .83           | .98            | —             | —              | —             | —              | —             | —               | —             | —               | —             | —               | 1                     |  |
| 1                     | 1                     | .30                               | .57           | .82            | 1.04          | 1.24           | 1.41          | —              | —             | —              | —             | —               | —             | —               | —             | —               | 1                     |  |
| 1                     | 1                     | .35                               | .68           | .98            | 1.25          | 1.50           | 1.72          | —              | —             | —              | —             | —               | —             | —               | —             | —               | 1                     |  |
| 2                     | 2                     | .40                               | .78           | 1.13           | 1.46          | 1.76           | 2.03          | 2.28           | —             | —              | —             | —               | —             | —               | —             | —               | 2                     |  |
| 2                     | 2                     | .46                               | .89           | 1.29           | 1.67          | 2.02           | 2.34          | 2.64           | —             | —              | —             | —               | —             | —               | —             | —               | 2                     |  |
| 2                     | 2                     | .51                               | .99           | 1.45           | 1.88          | 2.28           | 2.66          | 3.01           | 3.33          | —              | —             | —               | —             | —               | —             | —               | 2                     |  |
| 2                     | 2                     | .56                               | 1.09          | 1.60           | 2.08          | 2.54           | 2.97          | 3.37           | 3.75          | —              | —             | —               | —             | —               | —             | —               | 2                     |  |
| 3                     | 3                     | —                                 | 1.20          | 1.76           | 2.29          | 2.80           | 3.28          | 3.74           | 4.17          | 4.57           | —             | —               | —             | —               | —             | —               | 3                     |  |
| 3                     | 3                     | —                                 | 1.30          | 1.91           | 2.50          | 3.06           | 3.59          | 4.10           | 4.58          | 5.03           | —             | —               | —             | —               | —             | —               | 3                     |  |
| 3                     | 3                     | —                                 | 1.41          | 2.07           | 2.71          | 3.32           | 3.91          | 4.47           | 5.00          | 5.51           | 5.99          | —               | —             | —               | —             | —               | 3                     |  |
| 3                     | 3                     | —                                 | 1.51          | 2.23           | 2.92          | 3.58           | 4.22          | 4.83           | 5.42          | 5.98           | 6.51          | —               | —             | —               | —             | —               | 3                     |  |
| 4                     | 4                     | —                                 | 1.62          | 2.38           | 3.13          | 3.84           | 4.53          | 5.20           | 5.83          | 6.45           | 7.03          | 7.59            | —             | —               | —             | —               | 4                     |  |
| 4                     | 4                     | —                                 | 1.72          | 2.54           | 3.33          | 4.10           | 4.84          | 5.56           | 6.25          | 6.91           | 7.55          | 8.16            | —             | —               | —             | —               | 4                     |  |
| 4                     | 4                     | —                                 | 1.82          | 2.70           | 3.54          | 4.36           | 5.16          | 5.92           | 6.67          | 7.38           | 8.07          | 8.74            | 9.38          | —               | —             | —               | 4                     |  |
| 4                     | 4                     | —                                 | 1.93          | 2.85           | 3.75          | 4.62           | 5.47          | 6.29           | 7.08          | 7.85           | 8.59          | 9.31            | 10.00         | —               | —             | —               | 4                     |  |
| 5                     | 5                     | —                                 | 2.03          | 3.01           | 3.96          | 4.88           | 5.78          | 6.65           | 7.50          | 8.32           | 9.11          | 9.88            | 10.63         | 11.34           | —             | —               | 5                     |  |
| 5                     | 5                     | —                                 | 2.14          | 3.16           | 4.17          | 5.14           | 6.09          | 7.02           | 7.92          | 8.79           | 9.64          | 10.46           | 11.25         | 12.02           | —             | —               | 5                     |  |
| 5                     | 5                     | —                                 | 2.24          | 3.32           | 4.38          | 5.40           | 6.41          | 7.38           | 8.33          | 9.26           | 10.16         | 11.03           | 11.88         | 12.69           | 13.49         | —               | 5                     |  |
| 5                     | 5                     | —                                 | 2.34          | 3.48           | 4.58          | 5.66           | 6.72          | 7.75           | 8.75          | 9.73           | 10.68         | 11.60           | 12.50         | 13.37           | 14.22         | —               | 5                     |  |
| 6                     | 6                     | —                                 | 2.45          | 3.63           | 4.79          | 5.92           | 7.03          | 8.11           | 9.17          | 10.20          | 11.20         | 12.17           | 13.13         | 14.05           | 14.95         | 15.82           | 6                     |  |
| Sum of Flanges (ins.) | Sum of Flanges (ins.) | $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | Sum of Flanges (ins.) |  |

Thickness in Fractions of an Inch

TABLE OF THE WEIGHT OF ANGLE IRON IN LBS. PER LINEAL FOOT (continued).

| Thickness in Fractions of an Inch |                |                |                |                |                |                |                |                 |                 |               |                 |       |                 |                             | Sum of<br>Flanges<br>(ins.) |
|-----------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|---------------|-----------------|-------|-----------------|-----------------------------|-----------------------------|
| $\frac{3}{16}$                    | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{5}{8}$  | $\frac{11}{16}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 in. | $1\frac{1}{16}$ |                             |                             |
| 3.79                              | 5.00           | 6.18           | 7.34           | 8.48           | 9.58           | 10.66          | 11.72          | 12.75           | 13.75           | 14.72         | 15.68           | —     | —               | 6½                          |                             |
| 3.95                              | 5.21           | 6.45           | 7.66           | 8.84           | 10.00          | 11.13          | 12.24          | 13.32           | 14.38           | 15.40         | 16.41           | —     | —               | 6½                          |                             |
| 4.10                              | 5.42           | 6.71           | 7.97           | 9.21           | 10.42          | 11.60          | 12.76          | 13.89           | 15.00           | 16.08         | 17.14           | —     | —               | 6¾                          |                             |
| 4.26                              | 5.63           | 6.97           | 8.28           | 9.57           | 10.83          | 12.07          | 13.28          | 14.46           | 15.63           | 16.76         | 17.86           | 20.00 | —               | 7                           |                             |
| 4.41                              | 5.83           | 7.23           | 8.59           | 9.93           | 11.25          | 12.54          | 13.80          | 15.04           | 16.25           | 17.43         | 18.59           | 20.83 | —               | 7¼                          |                             |
| 4.57                              | 6.04           | 7.49           | 8.91           | 10.30          | 11.67          | 13.01          | 14.32          | 15.61           | 16.88           | 18.11         | 19.32           | 21.67 | —               | 7½                          |                             |
| 4.73                              | 6.25           | 7.75           | 9.22           | 10.66          | 12.08          | 13.48          | 14.84          | 16.18           | 17.50           | 18.79         | 20.05           | 22.50 | —               | 7¾                          |                             |
| 4.88                              | 6.46           | 8.01           | 9.53           | 11.03          | 12.50          | 13.95          | 15.36          | 16.76           | 18.13           | 19.47         | 20.78           | 23.33 | 24.57           | 8                           |                             |
| 5.04                              | 6.67           | 8.27           | 9.84           | 11.39          | 12.92          | 14.44          | 15.89          | 17.33           | 18.75           | 20.14         | 21.51           | 24.17 | 25.46           | 8¼                          |                             |
| 5.20                              | 6.88           | 8.53           | 10.16          | 11.76          | 13.33          | 14.88          | 16.41          | 17.90           | 19.38           | 20.82         | 22.24           | 25.00 | 26.34           | 8½                          |                             |
| 5.35                              | 7.08           | 8.79           | 10.47          | 12.12          | 13.75          | 15.35          | 16.93          | 18.48           | 20.00           | 21.50         | 22.97           | 25.83 | 27.23           | 8¾                          |                             |
| 5.51                              | 7.29           | 9.05           | 10.78          | 12.49          | 14.17          | 15.82          | 17.45          | 19.05           | 20.63           | 22.17         | 23.70           | 26.67 | 28.11           | 9                           |                             |
| 5.66                              | 7.50           | 9.31           | 11.09          | 12.85          | 14.58          | 16.29          | 17.97          | 19.62           | 21.25           | 22.85         | 24.43           | 27.50 | 29.00           | 9¼                          |                             |
| 5.82                              | 7.71           | 9.57           | 11.41          | 13.22          | 15.00          | 16.76          | 18.49          | 20.20           | 21.88           | 23.53         | 25.16           | 28.33 | 29.88           | 9½                          |                             |
| 5.98                              | 7.92           | 9.83           | 11.72          | 13.58          | 15.42          | 17.23          | 19.01          | 20.77           | 22.50           | 24.21         | 25.89           | 29.17 | 30.77           | 9¾                          |                             |
| 6.13                              | 8.13           | 10.09          | 12.08          | 13.95          | 15.83          | 17.70          | 19.53          | 21.34           | 23.13           | 24.88         | 26.61           | 30.00 | 31.65           | 10                          |                             |
| —                                 | 8.33           | 10.35          | 12.34          | 14.31          | 16.25          | 18.16          | 20.05          | 21.91           | 23.75           | 25.56         | 27.34           | 30.83 | 32.54           | 10¼                         |                             |
| —                                 | 8.54           | 10.61          | 12.66          | 14.67          | 16.67          | 18.63          | 20.57          | 22.49           | 24.38           | 26.24         | 28.07           | 31.67 | 33.42           | 10½                         |                             |
| —                                 | 8.75           | 10.87          | 12.97          | 15.04          | 17.08          | 19.10          | 21.09          | 23.06           | 25.00           | 26.91         | 28.80           | 32.50 | 34.31           | 10¾                         |                             |
| —                                 | 8.96           | 11.13          | 13.28          | 15.40          | 17.50          | 19.51          | 21.61          | 23.63           | 25.63           | 27.59         | 29.53           | 33.33 | 35.20           | 11                          |                             |
| —                                 | 9.17           | 11.39          | 13.59          | 15.77          | 17.92          | 20.04          | 22.14          | 24.21           | 26.25           | 28.27         | 30.26           | 34.17 | 36.08           | 11¼                         |                             |
| Sum of<br>flanges<br>(ins.)       | $\frac{3}{16}$ | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{11}{16}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | 1 in. | $1\frac{1}{16}$ | Sum of<br>Flanges<br>(ins.) |                             |

TABLE OF THE WEIGHT OF ANGLE IRON IN LBS. PER LINEAL FOOT (concluded).

| Sum of<br>Planges<br>(line.) | Thickness in Fractions of an Inch |               |                |               |                |               |                |               |                |               |                 |               | Sum of<br>Planges<br>(line.) |       |       |       |
|------------------------------|-----------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|------------------------------|-------|-------|-------|
|                              | $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ |                              |       |       |       |
| 11                           | 13.91                             | 16.13         | 18.33          | 20.51         | 22.66          | 24.78         | 26.88          | 28.95         | 30.99          | 33.01         | 35.00           | 36.97         | 38.91                        | 40.82 | 42.71 | 44.58 |
| 12                           | 14.22                             | 16.50         | 18.75          | 20.98         | 23.18          | 25.35         | 27.50          | 29.62         | 31.72          | 33.79         | 35.83           | 37.85         | 39.84                        | 41.81 | 43.75 | 45.67 |
| 13                           | 14.53                             | 16.86         | 19.17          | 21.45         | 23.70          | 25.92         | 28.13          | 30.30         | 32.45          | 34.57         | 36.67           | 38.74         | 40.78                        | 42.80 | 44.79 | 46.76 |
| 14                           | 14.84                             | 17.23         | 19.58          | 21.91         | 24.22          | 26.50         | 28.75          | 30.98         | 33.18          | 35.35         | 37.50           | 39.62         | 41.72                        | 43.79 | 45.83 | 47.85 |
| 15                           | 15.16                             | 17.59         | 20.00          | 22.38         | 24.74          | 27.07         | 29.38          | 31.65         | 33.91          | 36.13         | 38.33           | 40.51         | 42.66                        | 44.78 | 46.88 | 48.96 |
| 16                           | 15.47                             | 17.96         | 20.42          | 22.85         | 25.26          | 27.64         | 30.00          | 32.33         | 34.64          | 36.91         | 39.17           | 41.39         | 43.59                        | 45.77 | 47.92 | 50.00 |
| 17                           | 15.78                             | 18.32         | 20.83          | 23.32         | 25.78          | 28.22         | 30.63          | 33.01         | 35.36          | 37.70         | 40.00           | 42.28         | 44.53                        | 46.76 | 48.96 | 51.13 |
| 18                           | 16.09                             | 18.68         | 21.25          | 23.79         | 26.30          | 28.79         | 31.25          | 33.68         | 36.00          | 38.48         | 40.83           | 43.16         | 45.47                        | 47.75 | 50.00 | 52.28 |
| 19                           | 16.41                             | 19.03         | 21.67          | 24.26         | 26.82          | 29.36         | 31.88          | 34.36         | 36.82          | 39.26         | 41.67           | 44.05         | 46.41                        | 48.74 | 51.04 | 53.33 |
| 20                           | 16.72                             | 19.41         | 22.08          | 24.73         | 27.34          | 29.93         | 32.50          | 35.04         | 37.55          | 40.04         | 42.50           | 44.93         | 47.34                        | 49.73 | 52.08 | 54.45 |
| 21                           | 17.03                             | 19.78         | 22.50          | 25.20         | 27.86          | 30.51         | 33.13          | 35.72         | 38.28          | 40.82         | 43.33           | 45.82         | 48.28                        | 50.72 | 53.13 | 55.58 |
| 22                           | 17.34                             | 20.14         | 22.92          | 25.66         | 28.39          | 31.08         | 33.75          | 36.39         | 39.01          | 41.60         | 44.17           | 46.71         | 49.22                        | 51.71 | 54.17 | 56.65 |
| 23                           | 17.66                             | 20.51         | 23.33          | 26.13         | 28.91          | 31.65         | 34.38          | 37.07         | 39.74          | 42.38         | 45.00           | 47.59         | 50.16                        | 52.70 | 55.21 | 57.70 |
| 24                           | 17.97                             | 20.87         | 23.75          | 26.60         | 29.43          | 32.23         | 35.00          | 37.76         | 40.47          | 43.16         | 45.83           | 48.49         | 51.00                        | 53.68 | 56.25 | 58.80 |
| 25                           | 18.28                             | 21.24         | 24.17          | 27.07         | 29.95          | 32.80         | 35.63          | 38.48         | 41.20          | 43.95         | 46.67           | 49.36         | 52.03                        | 54.67 | 57.29 | 59.92 |
| 26                           | 18.59                             | 21.60         | 24.58          | 27.54         | 30.47          | 33.37         | 36.25          | 39.10         | 41.93          | 44.73         | 47.50           | 50.26         | 52.97                        | 55.66 | 58.32 | 61.00 |
| 27                           | 18.91                             | 21.97         | 25.00          | 28.01         | 30.99          | 33.95         | 36.88          | 39.78         | 42.66          | 45.51         | 48.33           | 51.13         | 53.91                        | 56.65 | 59.38 | 62.11 |
| 28                           | 19.22                             | 22.33         | 25.42          | 28.48         | 31.51          | 34.52         | 37.50          | 40.46         | 43.30          | 46.29         | 49.17           | 52.02         | 54.84                        | 57.64 | 60.42 | 63.22 |
| 29                           | 19.53                             | 22.70         | 25.83          | 28.95         | 32.03          | 35.09         | 38.13          | 41.13         | 44.11          | 47.07         | 50.00           | 52.90         | 55.78                        | 58.63 | 61.46 | 64.33 |
| 30                           |                                   |               |                |               |                |               |                |               |                |               |                 |               |                              |       |       |       |
| Sum of<br>Planges<br>(line.) | Thickness in Fractions of an Inch |               |                |               |                |               |                |               |                |               |                 |               | Sum of<br>Planges<br>(line.) |       |       |       |
|                              | $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ |                              |       |       |       |
| 31                           | 19.84                             | 23.07         | 26.25          | 29.43         | 32.60          | 35.75         | 38.88          | 42.00         | 45.11          | 48.22         | 51.33           | 54.44         | 57.55                        | 60.66 | 63.77 | 66.88 |
| 32                           | 20.15                             | 23.44         | 26.67          | 29.90         | 33.12          | 36.25         | 39.38          | 42.50         | 45.61          | 48.72         | 51.83           | 54.94         | 58.05                        | 61.16 | 64.27 | 67.38 |
| 33                           | 20.46                             | 23.81         | 27.08          | 30.37         | 33.64          | 36.77         | 39.89          | 43.01         | 46.12          | 49.23         | 52.34           | 55.45         | 58.56                        | 61.67 | 64.78 | 67.89 |
| 34                           | 20.77                             | 24.18         | 27.50          | 30.84         | 34.16          | 37.29         | 40.40          | 43.51         | 46.62          | 49.73         | 52.84           | 55.95         | 59.06                        | 62.17 | 65.28 | 68.39 |
| 35                           | 21.08                             | 24.55         | 27.92          | 31.31         | 34.68          | 37.81         | 40.88          | 44.00         | 47.11          | 50.22         | 53.33           | 56.44         | 59.55                        | 62.66 | 65.77 | 68.88 |
| 36                           | 21.39                             | 24.92         | 28.33          | 31.78         | 35.20          | 38.33         | 41.35          | 44.47         | 47.58          | 50.69         | 53.80           | 56.91         | 60.02                        | 63.13 | 66.24 | 69.35 |
| 37                           | 21.70                             | 25.29         | 28.75          | 32.25         | 35.72          | 38.85         | 41.82          | 44.90         | 48.01          | 51.12         | 54.23           | 57.34         | 60.45                        | 63.56 | 66.67 | 69.78 |
| 38                           | 22.01                             | 25.66         | 29.17          | 32.72         | 36.25          | 39.37         | 42.29          | 45.38         | 48.49          | 51.60         | 54.71           | 57.82         | 60.93                        | 64.04 | 67.15 | 70.26 |
| 39                           | 22.32                             | 26.03         | 29.58          | 33.19         | 36.77          | 39.89         | 42.76          | 45.83         | 48.94          | 52.05         | 55.16           | 58.27         | 61.38                        | 64.49 | 67.60 | 70.71 |
| 40                           | 22.63                             | 26.40         | 30.00          | 33.66         | 37.29          | 40.40         | 43.25          | 46.33         | 49.44          | 52.55         | 55.66           | 58.77         | 61.88                        | 64.99 | 68.10 | 71.21 |
| 41                           | 22.94                             | 26.77         | 30.42          | 34.13         | 37.81          | 40.92         | 43.72          | 46.80         | 49.91          | 53.02         | 56.13           | 59.24         | 62.35                        | 65.46 | 68.57 | 71.68 |
| 42                           | 23.25                             | 27.14         | 30.83          | 34.60         | 38.33          | 41.44         | 44.19          | 47.27         | 50.38          | 53.49         | 56.60           | 59.71         | 62.82                        | 65.93 | 69.04 | 72.19 |
| 43                           | 23.56                             | 27.51         | 31.25          | 35.07         | 38.85          | 41.96         | 44.66          | 47.74         | 50.85          | 53.96         | 57.07           | 60.18         | 63.29                        | 66.40 | 69.51 | 72.62 |
| 44                           | 23.87                             | 27.88         | 31.67          | 35.54         | 39.37          | 42.48         | 45.13          | 48.21         | 51.32          | 54.43         | 57.54           | 60.65         | 63.76                        | 66.87 | 70.00 | 73.11 |
| 45                           | 24.18                             | 28.25         | 32.08          | 36.01         | 39.89          | 42.99         | 45.60          | 48.68         | 51.79          | 54.90         | 58.01           | 61.12         | 64.23                        | 67.34 | 70.45 | 73.56 |
| 46                           | 24.49                             | 28.62         | 32.50          | 36.48         | 40.40          | 43.51         | 46.07          | 49.15         | 52.26          | 55.37         | 58.48           | 61.59         | 64.70                        | 67.81 | 70.92 | 74.03 |
| 47                           | 24.80                             | 28.99         | 32.92          | 36.95         | 40.92          | 44.02         | 46.54          | 49.62         | 52.73          | 55.84         | 58.95           | 62.06         | 65.17                        | 68.28 | 71.39 | 74.50 |
| 48                           | 25.11                             | 29.36         | 33.33          | 37.42         | 41.44          | 44.54         | 47.01          | 50.09         | 53.20          | 56.31         | 59.42           | 62.53         | 65.64                        | 68.75 | 71.86 | 74.97 |
| 49                           | 25.42                             | 29.73         | 33.75          | 37.89         | 41.96          | 45.06         | 47.48          | 50.56         | 53.67          | 56.78         | 59.89           | 63.00         | 66.11                        | 69.22 | 72.33 | 75.44 |
| 50                           | 25.73                             | 30.10         | 34.17          | 38.36         | 42.48          | 45.58         | 47.95          | 51.03         | 54.14          | 57.25         | 60.36           | 63.47         | 66.58                        | 69.69 | 72.80 | 75.91 |

TABLE OF THE WEIGHT OF MALLEABLE ROUND AND SQUARE IRON IN LBS. PER LINEAL FOOT.

| Width<br>in Ins. | Weight in Lbs. |         | Width<br>in Ins. | Weight in Lbs. |        | Width<br>in Ins. | Weight in Lbs. |        |
|------------------|----------------|---------|------------------|----------------|--------|------------------|----------------|--------|
|                  | Round          | Square  |                  | Round          | Square |                  | Round          | Square |
| 3/4              | 0.93           | 1.17    | 3                | 36.812         | 46.875 | 9                | 167.53         | 213.33 |
| 7/8              | 1.64           | 2.08    | 4                | 39.306         | 50.052 | 10               | 172.81         | 220.05 |
| 1                | 2.56           | 3.26    | 5                | 41.884         | 53.333 | 11               | 178.17         | 226.88 |
| 1 1/8            | 3.68           | 4.69    | 6                | 44.542         | 56.719 | 12               | 183.61         | 233.80 |
| 1 1/4            | 5.01           | 6.38    | 7                | 47.283         | 60.208 | 13               | 189.13         | 240.83 |
| 1 1/2            | 6.54           | 8.33    | 8                | 50.105         | 63.802 | 14               | 194.73         | 247.97 |
| 1 3/4            | 8.28           | 10.55   | 9                | 53.009         | 67.500 | 15               | 200.42         | 255.21 |
| 2                | 10.23          | 13.02   | 10               | 55.995         | 71.302 | 16               | 206.19         | 262.55 |
| 2 1/8            | 12.37          | 15.76   | 11               | 59.062         | 75.208 | 17               | 212.04         | 270.00 |
| 2 1/4            | 14.73          | 18.75   | 12               | 62.212         | 79.219 | 18               | 217.97         | 277.55 |
| 2 1/2            | 17.28          | 22.01   | 13               | 65.443         | 83.333 | 19               | 223.98         | 285.21 |
| 2 3/4            | 20.04          | 25.52   | 14               | 68.756         | 87.552 | 20               | 230.07         | 292.97 |
| 3                | 23.00          | 29.30   | 15               | 72.151         | 91.875 | 21               | 236.25         | 300.83 |
| 3 1/8            | 26.18          | 33.33   | 16               | 75.628         | 96.302 | 22               | 242.51         | 308.88 |
| 3 1/4            | 30.313         | 42.19   | 17               | 79.186         | 100.83 | 23               | 248.85         | 316.88 |
| 3 1/2            | 40.90          | 52.08   | 18               | 82.827         | 105.47 | 24               | 255.27         | 325.05 |
| 3 3/4            | 49.49          | 63.02   | 19               | 86.549         | 110.21 | 25               | 261.77         | 333.33 |
| 4                | 58.90          | 75.00   | 20               | 90.353         | 115.05 | 26               | 268.36         | 341.72 |
| 4 1/8            | 69.12          | 88.02   | 21               | 94.238         | 120.00 | 27               | 275.03         | 350.21 |
| 4 1/4            | 80.17          | 102.08  | 22               | 98.206         | 125.05 | 28               | 281.77         | 358.80 |
| 4 1/2            | 92.03          | 117.19  | 23               | 102.26         | 130.21 | 29               | 288.60         | 367.50 |
| 4 3/4            | 104.71         | 133.33  | 24               | 106.39         | 135.47 | 30               | 295.52         | 376.30 |
| 5                | 118.21         | 150.52  | 25               | 110.60         | 140.83 | 31               | 302.51         | 385.21 |
| 5 1/8            | 132.52         | 168.75  | 26               | 114.89         | 146.30 | 32               | 309.59         | 394.22 |
| 5 1/4            | 147.66         | 188.02  | 27               | 119.27         | 151.88 | 33               | 316.75         | 403.33 |
| 5 1/2            | 163.61         | 208.33  | 28               | 123.73         | 157.55 | 34               | 323.99         | 412.55 |
| 5 3/4            | 180.38         | 230.69  | 29               | 128.27         | 163.33 | 35               | 331.31         | 421.88 |
| 6                | 197.97         | 255.208 | 30               | 132.89         | 169.22 | 36               | 338.71         | 431.30 |
| 6 1/8            | 216.37         | 275.52  | 31               | 137.60         | 175.21 | 37               | 346.20         | 440.83 |
| 6 1/4            | 235.60         | 300.00  | 32               | 142.48         | 181.30 | 38               | 353.76         | 450.47 |
| 6 1/2            | 255.64         | 325.52  | 33               | 147.25         | 187.50 | 39               | 361.41         | 460.21 |
| 6 3/4            | 276.50         | 352.08  | 34               | 152.20         | 193.80 | 40               | 369.14         | 470.05 |
| 7                | 298.18         | 379.69  | 35               | 157.23         | 200.21 | 41               | 376.95         | 480.00 |
| 7 1/8            | 320.67         | 408.33  | 36               | 162.34         | 206.72 |                  |                |        |
| 7 1/4            | 343.99         | 438.02  |                  |                |        |                  |                |        |
| 7 1/2            |                |         |                  |                |        |                  |                |        |
| 7 3/4            |                |         |                  |                |        |                  |                |        |
| 8                |                |         |                  |                |        |                  |                |        |
| Width<br>in Ins. | Weight in Lbs. |         | Width<br>in Ins. | Weight in Lbs. |        | Width<br>in Ins. | Weight in Lbs. |        |
|                  | Round          | Square  |                  | Round          | Square |                  | Round          | Square |
|                  | Weight in Lbs. |         |                  | Weight in Lbs. |        |                  | Weight in Lbs. |        |

TABLE OF THE WEIGHT OF THE BUTTERLY COMPANY'S PATENT SOLID WROUGHT-IRON DECK-BEAMS.

| No. of Section | Depth of Beam (ins.) | Width of Top Flange (ins.) | Width of Bulb (ins.) | Average Weight per Lineal Foot (lbs.) | No. of Section | Depth of Beam (ins.) | Width of Top Flange (ins.) | Width of Bulb (ins.) | Average Weight per Lineal Foot (lbs.) |
|----------------|----------------------|----------------------------|----------------------|---------------------------------------|----------------|----------------------|----------------------------|----------------------|---------------------------------------|
| 1              | 16                   | 6 $\frac{1}{2}$            | 3 $\frac{1}{2}$      | 52 to 56                              | 11             | —                    | —                          | —                    | —                                     |
| 2              | 15                   | 6 $\frac{1}{2}$            | 3 $\frac{1}{2}$      | 52 " 55                               | 12             | 8                    | 5 $\frac{1}{2}$            | 17 $\frac{1}{2}$     | 27 to 28                              |
| 3              | 14                   | 6 $\frac{1}{2}$            | 3 $\frac{1}{2}$      | 50 " 54                               | 13             | 7                    | 5                          | 17 $\frac{1}{2}$     | 22 " 25                               |
| 4              | 13                   | 6 $\frac{1}{2}$            | 3 $\frac{1}{2}$      | 49 " 53                               | 14             | —                    | —                          | —                    | —                                     |
| 5              | 12                   | 6 $\frac{1}{2}$            | 3 $\frac{1}{2}$      | 47 " 50                               | 15             | 6                    | 5                          | 17 $\frac{1}{2}$     | 19 to 20                              |
| 6              | 11                   | 6 $\frac{1}{2}$            | 2 $\frac{1}{2}$      | 43 " 44                               | 16             | —                    | —                          | —                    | —                                     |
| 7              | 10                   | 6                          | 2 $\frac{1}{2}$      | 35 " 37                               | 17             | 5                    | 4                          | 17 $\frac{1}{2}$     | 14 $\frac{1}{2}$ to 16                |
| 8              | —                    | —                          | —                    | —                                     | 18             | 4                    | 3                          | 17 $\frac{1}{2}$     | 9 $\frac{1}{2}$                       |
| 9              | 9                    | 6 $\frac{1}{2}$            | 3 $\frac{1}{2}$      | 42 to 45                              | 19*            | 6 $\frac{1}{2}$      | 8 $\frac{1}{2}$            | 17 $\frac{1}{2}$     | 16 to 17                              |
| 10             | 9                    | 5 $\frac{1}{2}$            | 2                    | 31 " 33                               | 20*            | 5                    | 2 $\frac{1}{2}$            | 17 $\frac{1}{2}$     | 11 $\frac{1}{2}$ to 12                |

\* These two are bulb angle-iron; all the others are bulb T-irons.

TABLE OF THE WEIGHT OF SOLID WROUGHT-IRON BULB-PLATE BEAMS.

| Depth of Beam (ins.) | Thickness of Web (ins.) | Width of Bulb (ins.) | Weight per Lineal Foot (lbs.) | Depth of Beam (ins.) | Thickness of Web (ins.) | Width of Bulb (ins.) | Weight per Lineal Foot (lbs.) | Depth of Beam (ins.) | Thickness of Web (ins.) | Width of Bulb (ins.) | Weight per Lineal Foot (lbs.) |
|----------------------|-------------------------|----------------------|-------------------------------|----------------------|-------------------------|----------------------|-------------------------------|----------------------|-------------------------|----------------------|-------------------------------|
| 12                   | 1 $\frac{1}{8}$         | 2                    | 39-20                         | 11                   | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 16-64                         | 10                   | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 9-02                          |
| "                    | 1 $\frac{1}{8}$         | 2                    | 31-40                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 13-55                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 6-85                          |
| "                    | 1 $\frac{1}{8}$         | 1                    | 24-09                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 11-21                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 14-1                          |
| 11                   | 1 $\frac{1}{8}$         | 2                    | 36-70                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 8-52                          | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 12-06                         |
| "                    | 1 $\frac{1}{8}$         | 2                    | 29-32                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 17-42                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 9-80                          |
| "                    | 1 $\frac{1}{8}$         | 1                    | 22-42                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 14-98                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 7-98                          |
| 10                   | 1 $\frac{1}{8}$         | 2                    | 24-92                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 12-30                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 6-02                          |
| "                    | 1 $\frac{1}{8}$         | 1                    | 23-70                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 10-06                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 12-42                         |
| "                    | 1 $\frac{1}{8}$         | 1                    | 20-76                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 7-69                          | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 10-60                         |
| "                    | 1 $\frac{1}{8}$         | 1                    | 17-54                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 15-76                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 8-55                          |
| "                    | 1 $\frac{1}{8}$         | 1                    | 14-80                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 13-52                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 6-94                          |
| 9                    | 1 $\frac{1}{8}$         | 1                    | 19-09                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 11-05                         | "                    | 1 $\frac{1}{8}$         | 1 $\frac{1}{8}$      | 5-19                          |

TABLE OF THE WEIGHT OF DECK CAULKING IN LBS. PER FOOT RUN.

|                           |                |                |               |                |               |                 |               |                 |
|---------------------------|----------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|
| Thickness of plank (ins.) | 7              | 6              | 5             | 4              | 3             | 2 $\frac{1}{2}$ | 2             | 1 $\frac{1}{2}$ |
| Size of seam (ins.)       | $\frac{7}{16}$ | $\frac{7}{16}$ | $\frac{3}{8}$ | $\frac{5}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$  | $\frac{1}{4}$ | $\frac{1}{8}$   |
| Weight per foot run       | 70             | 60             | 50            | 40             | 30            | 25              | 18            | 10              |



TABLE GIVING WEIGHTS OF GIRDER AND BEAM IRON, AS FURNISHED BY MESSRS. JOHN WALLACE AND CO., OF LONDON AND DUNDEE.



| Maker's No. of Plate  | Maker's No. of Section | Depth of Web in Ins. | Thickness of Web in Ins. | Width of Flanges in Ins. | Weight per Foot in Lbs. | Maker's No. of Plate | Maker's No. of Section | Depth of Web in Ins. | Thickness of Web in Ins. | Width of Flanges in Ins. | Weight per Foot in Lbs. |
|---|------------------------|----------------------|--------------------------|--------------------------|-------------------------|----------------------|------------------------|----------------------|--------------------------|--------------------------|-------------------------|
| GIRDER IRON  |                        |                      |                          |                          |                         |                      |                        |                      |                          |                          |                         |
| 1   | 62                     | 20                   |                          | 7                        | 80                      | 21                   | 57a                    | 8                    |                          | 6 1/2                    | 38                      |
| 1 1/2   | 62b                    | 20                   |                          | 7 1/2                    | 100                     | 22                   | 14                     | 8                    |                          | 5 1/2                    | 29                      |
| 2   | 63                     | 19                   |                          | 6 3/4                    | 88                      | 22                   | 14a                    | 8                    |                          | 5 1/2                    | 28                      |
| 2 1/2   | 63a                    | 19                   |                          | 7 1/4                    | 97                      | 22                   | 16                     | 8                    |                          | 4 1/2                    | 23                      |
| 3   | 64                     | 18                   |                          | 6 3/4                    | 77                      | 22                   | 15a                    | 8                    |                          | 4 1/2                    | 25                      |
| 3 1/2   | 64a                    | 18                   |                          | 6 3/4                    | 88                      | 23                   | 6                      | 8                    |                          | 2 1/2                    | 16                      |
| 4   | 65                     | 17                   |                          | 6 3/4                    | 70                      | 23                   | 6a                     | 8                    |                          | 2 1/2                    | 13                      |
| 4 1/2   | 65a                    | 17                   |                          | 6 3/4                    | 77                      | 24                   | 31                     | 7                    |                          | 4                        | 20                      |
| 5   | 64                     | 16                   |                          | 5 1/2                    | 68                      | 24                   | 31a                    | 7                    |                          | 4 1/2                    | 24                      |
| 5 1/2   | 64a                    | 16                   |                          | 5 1/2                    | 70                      | 24                   | 13                     | 7 1/2                |                          | 3 3/4                    | 18                      |
| 6   | 66                     | 15                   |                          | 5 1/2                    | 50                      | 24                   | 13a                    | 7 1/2                |                          | 3 3/4                    | 22                      |
| 6 1/2   | 66a                    | 15                   |                          | 5 1/2                    | 60                      | 23                   | 5                      | 7                    |                          | 2 3/4                    | 13                      |
| 7   | 69                     | 14                   |                          | 5 1/2                    | 55                      | 23                   | 5a                     | 7                    |                          | 2 3/4                    | 16                      |
| 7 1/2   | 69a                    | 14                   |                          | 5 1/2                    | 46                      | 25                   | 13                     | 6 1/2                |                          | 3 3/4                    | 14                      |
| 8   | 65                     | 12 1/2               |                          | 5 1/2                    | 45                      | 25                   | 12a                    | 6 1/2                |                          | 3 3/4                    | 20                      |
| 8 1/2   | 65a                    | 12 1/2               |                          | 5 1/2                    | 43                      | 20                   | 4                      | 6 1/2                |                          | 3 3/4                    | 11                      |
| 9   | 67                     | 12                   |                          | 7 3/4                    | 60                      | 20                   | 4a                     | 6 1/2                |                          | 2 1/2                    | 14                      |
| 10  | 67a                    | 12                   |                          | 7 3/4                    | 55                      | 25                   | 19                     | 6                    |                          | 5 1/2                    | 26                      |
| 11  | 68                     | 12                   |                          | 6 1/2                    | 56                      | 25                   | 19a                    | 6                    |                          | 5 1/2                    | 20                      |
| 11 1/2  | 68a                    | 12                   |                          | 6 1/2                    | 59                      | 26                   | 20                     | 6                    |                          | 4 1/2                    | 14                      |
| 12  | 10                     | 12                   |                          | 5 1/2                    | 40                      | 26                   | 20a                    | 6                    |                          | 4 1/2                    | 22                      |
| 12 1/2  | 10a                    | 12                   |                          | 5 1/2                    | 50                      | 26                   | 30                     | 6                    |                          | 3                        | 14                      |
| 13  | 58                     | 11                   |                          | 5 1/2                    | 66                      | 26                   | 30a                    | 6 1/2                |                          | 3 1/2                    | 18                      |
| 13 1/2  | 58a                    | 11                   |                          | 5 1/2                    | 43                      | 17                   | 16                     | 5 1/2                |                          | 2 1/2                    | 19                      |
| 14  | 25                     | 10                   |                          | 5 1/2                    | 35                      | 17                   | 16a                    | 5 1/2                |                          | 3                        | 15                      |
| 14 1/2  | 25a                    | 10                   |                          | 5 1/2                    | 45                      | 18                   | 9                      | 5 1/2                |                          | 3                        | 10                      |
| 15  | 9                      | 10                   |                          | 4 1/2                    | 30                      | 18                   | 8a                     | 5 1/2                |                          | 2 1/2                    | 12                      |
| 15 1/2  | 9a                     | 10                   |                          | 4 1/2                    | 40                      | 16                   | 18                     | 5                    |                          | 4 1/2                    | 23                      |
| 16  | 23                     | 9 1/2                |                          | 4 1/2                    | 27                      | 16                   | 18a                    | 5                    |                          | 4 1/2                    | 26                      |
| 16 1/2  | 23a                    | 9 1/2                |                          | 4 1/2                    | 32                      | 19                   | 17                     | 5                    |                          | 3                        | 13                      |
| 17  | 8                      | 9 1/2                |                          | 3 3/4                    | 22                      | 19                   | 17a                    | 5                    |                          | 3 1/2                    | 18                      |
| 17 1/2  | 8a                     | 9 1/2                |                          | 3 3/4                    | 30                      | 15                   | 2                      | 4 1/2                |                          | 2                        | 8                       |
| 18  | 11                     | 9 1/2                |                          | 3 1/2                    | 20                      | 15                   | 2a                     | 4 1/2                |                          | 2 1/2                    | 10                      |
| 18 1/2  | 11a                    | 9 1/2                |                          | 3 1/2                    | 24                      | 14                   | 52                     | 4                    |                          | 3                        | 11                      |
| 21  | 59                     | 8                    |                          | 6                        | 39                      | 14                   | 52a                    | 4                    |                          | 3 1/2                    | 13                      |
| 19  | 56                     | 9                    |                          | 4                        | 26                      | 12                   | 1                      | 4                    |                          | 2                        | 7                       |
| 19 1/2  | 56a                    | 9                    |                          | 4 1/2                    | 29                      | 13                   | 1a                     | 4                    |                          | 2 1/2                    | 9                       |
| 20  | 7                      | 8 1/2                |                          | 2 1/2                    | 18                      | 13                   | 0                      | 3 1/2                |                          | 2                        | 6 1/2                   |
| 20 1/2  | 7a                     | 8 1/2                |                          | 2 1/2                    | 22                      | 13                   | 0a                     | 3 1/2                |                          | 2 1/2                    | 8                       |
| 21  | 57                     | 8                    |                          | 6                        | 35                      | 11                   | 24                     | 3                    |                          | 3                        | 8                       |
| BEAM IRON  |                        |                      |                          |                          |                         |                      |                        |                      |                          |                          |                         |
| 32  | 75                     | 12                   |                          | 8                        | 49                      | 34                   | 44a                    | 7                    |                          | 4 1/2                    | 24                      |
| 32 1/2  | 74                     | 10 1/2               |                          | 5 1/2                    | 36                      | 34                   | 45                     | 6                    |                          | 4 1/2                    | 19                      |
| 33  | 78                     | 9                    |                          | 5 3/4                    | 30                      | 34                   | 43a                    | 6                    |                          | 4 1/2                    | 22                      |
| 33 1/2  | 72                     | 8                    |                          | 5 3/4                    | 25                      | 35                   | 42                     | 6                    |                          | 3 1/2                    | 12                      |
| 33 1/2  | 71                     | 7                    |                          | 5 3/4                    | 22                      | 35                   | 42a                    | 6                    |                          | 3 1/2                    | 16 1/2                  |
| 33 1/2  | 70                     | 6                    |                          | 4 3/4                    | 16                      | 35                   | 41                     | 4                    |                          | 3                        | 9                       |
| 34  | 44                     | 7                    |                          | 4 1/2                    | 20                      | 35                   | 41a                    | 4                    |                          | 3 1/2                    | 16 1/2                  |

TABLE OF THE WEIGHT OF MALLEABLE FLAT STEEL IN LBS. PER LINEAL FOOT.

| Width<br>of Plate<br>(ins.) | Thickness in Fractions of an Inch |               |                |               |                |               |                |               |                |               |                 |               |                 |               |                |                | Width<br>of Plate<br>(ins.) |
|-----------------------------|-----------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|-----------------|---------------|-----------------|---------------|----------------|----------------|-----------------------------|
|                             | $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $1\frac{1}{8}$ | $1\frac{1}{4}$ |                             |
| 1                           | .21                               | .43           | .64            | .85           | 1.06           | 1.28          | 1.49           | 1.70          | 1.91           | 2.13          | 2.34            | 2.55          | 2.76            | 2.98          | 3.19           | 3.40           | 1                           |
| 1 $\frac{1}{4}$             | .27                               | .53           | .80            | 1.06          | 1.33           | 1.59          | 1.86           | 2.13          | 2.39           | 2.66          | 2.92            | 3.19          | 3.45            | 3.72          | 3.98           | 4.25           | 1 $\frac{1}{4}$             |
| 1 $\frac{1}{2}$             | .32                               | .64           | .96            | 1.28          | 1.59           | 1.91          | 2.23           | 2.55          | 2.87           | 3.19          | 3.51            | 3.83          | 4.14            | 4.46          | 4.78           | 5.10           | 1 $\frac{1}{2}$             |
| 1 $\frac{3}{4}$             | .37                               | .74           | 1.12           | 1.49          | 1.86           | 2.23          | 2.60           | 2.98          | 3.35           | 3.72          | 4.09            | 4.46          | 4.83            | 5.21          | 5.58           | 5.95           | 1 $\frac{3}{4}$             |
| 2                           | .43                               | .85           | 1.28           | 1.70          | 2.13           | 2.55          | 2.98           | 3.40          | 3.83           | 4.25          | 4.68            | 5.10          | 5.53            | 5.95          | 6.38           | 6.80           | 2                           |
| 2 $\frac{1}{4}$             | .48                               | .96           | 1.43           | 1.91          | 2.39           | 2.87          | 3.35           | 3.82          | 4.30           | 4.78          | 5.26            | 5.74          | 6.22            | 6.69          | 7.17           | 7.65           | 2 $\frac{1}{4}$             |
| 2 $\frac{1}{2}$             | .53                               | 1.06          | 1.59           | 2.13          | 2.66           | 3.19          | 3.72           | 4.25          | 4.78           | 5.31          | 5.84            | 6.38          | 6.91            | 7.44          | 7.97           | 8.50           | 2 $\frac{1}{2}$             |
| 2 $\frac{3}{4}$             | .58                               | 1.17          | 1.75           | 2.34          | 2.92           | 3.51          | 4.09           | 4.68          | 5.26           | 5.84          | 6.43            | 7.01          | 7.60            | 8.18          | 8.77           | 9.35           | 2 $\frac{3}{4}$             |
| 3                           | .64                               | 1.28          | 1.91           | 2.55          | 3.19           | 3.83          | 4.46           | 5.10          | 5.74           | 6.38          | 7.01            | 7.65          | 8.29            | 8.93          | 9.56           | 10.20          | 3                           |
| 3 $\frac{1}{4}$             | .69                               | 1.38          | 2.07           | 2.76          | 3.45           | 4.14          | 4.83           | 5.53          | 6.22           | 6.91          | 7.60            | 8.29          | 8.98            | 9.67          | 10.36          | 11.05          | 3 $\frac{1}{4}$             |
| 3 $\frac{1}{2}$             | .74                               | 1.49          | 2.23           | 2.98          | 3.72           | 4.46          | 5.21           | 5.95          | 6.69           | 7.44          | 8.18            | 8.93          | 9.67            | 10.41         | 11.16          | 11.90          | 3 $\frac{1}{2}$             |
| 3 $\frac{3}{4}$             | .80                               | 1.59          | 2.39           | 3.19          | 3.98           | 4.78          | 5.58           | 6.38          | 7.17           | 7.97          | 8.77            | 9.56          | 10.36           | 11.16         | 11.95          | 12.75          | 3 $\frac{3}{4}$             |
| 4                           | .85                               | 1.70          | 2.55           | 3.40          | 4.25           | 5.10          | 5.95           | 6.80          | 7.65           | 8.50          | 9.35            | 10.20         | 11.05           | 11.90         | 12.75          | 13.50          | 4                           |
| 4 $\frac{1}{4}$             | .90                               | 1.81          | 2.71           | 3.61          | 4.52           | 5.43          | 6.32           | 7.22          | 8.13           | 9.03          | 9.93            | 10.84         | 11.74           | 12.64         | 13.55          | 14.45          | 4 $\frac{1}{4}$             |
| 4 $\frac{1}{2}$             | .96                               | 1.91          | 2.87           | 3.83          | 4.78           | 5.74          | 6.69           | 7.65          | 8.61           | 9.56          | 10.52           | 11.48         | 12.43           | 13.39         | 14.34          | 15.30          | 4 $\frac{1}{2}$             |
| 4 $\frac{3}{4}$             | 1.01                              | 2.02          | 3.03           | 4.04          | 5.05           | 6.06          | 7.07           | 8.08          | 9.08           | 10.09         | 11.10           | 12.11         | 13.12           | 14.13         | 15.14          | 16.15          | 4 $\frac{3}{4}$             |
| 5                           | 1.06                              | 2.13          | 3.10           | 4.25          | 5.31           | 6.38          | 7.44           | 8.50          | 9.56           | 10.63         | 11.69           | 12.75         | 13.81           | 14.86         | 15.94          | 17.00          | 5                           |
| 5 $\frac{1}{4}$             | 1.12                              | 2.23          | 3.25           | 4.46          | 5.58           | 6.69          | 7.81           | 8.93          | 10.04          | 11.16         | 12.27           | 13.39         | 14.50           | 15.62         | 16.73          | 17.85          | 5 $\frac{1}{4}$             |
| 5 $\frac{1}{2}$             | 1.17                              | 2.34          | 3.51           | 4.68          | 5.84           | 7.01          | 8.18           | 9.35          | 10.52          | 11.69         | 12.86           | 14.03         | 15.19           | 16.36         | 17.53          | 18.70          | 5 $\frac{1}{2}$             |
| 5 $\frac{3}{4}$             | 1.22                              | 2.44          | 3.67           | 4.89          | 6.11           | 7.33          | 8.55           | 9.78          | 11.00          | 12.22         | 13.44           | 14.66         | 15.88           | 17.11         | 18.33          | 19.55          | 5 $\frac{3}{4}$             |
| 6                           | 1.28                              | 2.55          | 3.83           | 5.10          | 6.38           | 7.65          | 8.93           | 10.20         | 11.48          | 12.75         | 14.03           | 15.30         | 16.58           | 17.85         | 19.13          | 20.40          | 6                           |
| Width<br>of Plate<br>(ins.) | $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{9}{16}$ | $\frac{5}{8}$ | $\frac{11}{16}$ | $\frac{3}{4}$ | $\frac{13}{16}$ | $\frac{7}{8}$ | $1\frac{1}{8}$ | $1\frac{1}{4}$ | Width<br>of Plate<br>(ins.) |

TABLE OF THE WEIGHT OF MALLEABLE FLAT STEEL IN LBS. PER LINEAL FOOT (concluded).

| Thickness in Fractions of an Inch |               |                |               |                |               |                |               |               |               |               |                 |               |               |               |               |                |                         |
|-----------------------------------|---------------|----------------|---------------|----------------|---------------|----------------|---------------|---------------|---------------|---------------|-----------------|---------------|---------------|---------------|---------------|----------------|-------------------------|
| $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | $\frac{1}{2}$ | $\frac{3}{4}$ | $\frac{1}{2}$ | $\frac{1}{4}$ | $\frac{1}{16}$ | Breadth of Plate (ins.) |
| 1.33                              | 2.66          | 3.98           | 5.31          | 6.64           | 7.97          | 9.30           | 10.63         | 11.95         | 13.28         | 14.61         | 15.94           | 17.27         | 18.59         | 19.92         | 21.25         | 6              | 6                       |
| 1.38                              | 2.76          | 4.14           | 5.53          | 6.91           | 8.29          | 9.67           | 11.05         | 12.43         | 13.81         | 15.19         | 16.58           | 17.96         | 19.34         | 20.72         | 22.10         | 6              | 8                       |
| 1.43                              | 2.87          | 4.30           | 5.74          | 7.17           | 8.61          | 10.04          | 11.48         | 12.91         | 14.34         | 15.78         | 17.21           | 18.65         | 20.08         | 21.52         | 22.95         | 6              | 6                       |
| 1.49                              | 2.98          | 4.46           | 5.95          | 7.44           | 8.93          | 10.41          | 11.90         | 13.39         | 14.88         | 16.36         | 17.85           | 19.34         | 20.83         | 22.31         | 23.80         | 7              | 7                       |
| 1.54                              | 3.08          | 4.62           | 6.16          | 7.70           | 9.24          | 10.78          | 12.33         | 13.87         | 15.41         | 16.95         | 18.49           | 20.03         | 21.57         | 23.11         | 24.65         | 7              | 7                       |
| 1.59                              | 3.19          | 4.78           | 6.38          | 7.97           | 9.56          | 11.16          | 12.75         | 14.34         | 15.94         | 17.53         | 19.13           | 20.72         | 22.31         | 23.91         | 25.50         | 7              | 7                       |
| 1.65                              | 3.29          | 4.94           | 6.59          | 8.23           | 9.88          | 11.53          | 13.18         | 14.82         | 16.47         | 18.12         | 19.76           | 21.41         | 23.06         | 24.70         | 26.35         | 7              | 7                       |
| 1.70                              | 3.40          | 5.10           | 6.84          | 8.50           | 10.20         | 11.90          | 13.60         | 15.30         | 17.00         | 18.70         | 20.40           | 22.10         | 23.80         | 25.50         | 27.20         | 8              | 8                       |
| 1.75                              | 3.51          | 5.26           | 7.01          | 8.77           | 10.52         | 12.27          | 14.03         | 15.78         | 17.53         | 19.28         | 21.04           | 22.79         | 24.54         | 26.30         | 28.05         | 8              | 8                       |
| 1.81                              | 3.61          | 5.42           | 7.23          | 9.03           | 10.84         | 12.64          | 14.45         | 16.26         | 18.06         | 19.87         | 21.68           | 23.48         | 25.29         | 27.09         | 28.90         | 8              | 8                       |
| 1.86                              | 3.72          | 5.58           | 7.44          | 9.30           | 11.16         | 13.02          | 14.88         | 16.73         | 18.59         | 20.45         | 22.31           | 24.17         | 26.03         | 27.89         | 29.75         | 8              | 8                       |
| 1.91                              | 3.83          | 5.74           | 7.65          | 9.56           | 11.48         | 13.39          | 15.30         | 17.21         | 19.13         | 21.04         | 22.95           | 24.86         | 26.78         | 28.69         | 30.60         | 9              | 9                       |
| 1.97                              | 3.93          | 5.90           | 7.86          | 9.83           | 11.79         | 13.76          | 15.73         | 17.69         | 19.66         | 21.62         | 23.59           | 25.55         | 27.52         | 29.48         | 31.45         | 9              | 9                       |
| 2.02                              | 4.04          | 6.06           | 8.08          | 10.00          | 12.11         | 14.13          | 16.16         | 18.17         | 20.19         | 22.21         | 24.23           | 26.24         | 28.26         | 30.28         | 32.30         | 9              | 9                       |
| 2.07                              | 4.14          | 6.22           | 8.29          | 10.36          | 12.43         | 14.50          | 16.58         | 18.64         | 20.72         | 22.79         | 24.86           | 26.93         | 29.01         | 31.08         | 33.15         | 9              | 9                       |
| 2.13                              | 4.25          | 6.38           | 8.50          | 10.63          | 12.75         | 14.88          | 17.00         | 19.13         | 21.25         | 23.38         | 25.50           | 27.63         | 29.75         | 31.88         | 34.00         | 10             | 10                      |
| 2.18                              | 4.36          | 6.53           | 8.71          | 10.89          | 13.07         | 15.25          | 17.43         | 19.60         | 21.78         | 23.96         | 26.14           | 28.32         | 30.49         | 32.67         | 34.85         | 10             | 10                      |
| 2.23                              | 4.46          | 6.69           | 8.93          | 11.16          | 13.39         | 15.62          | 17.85         | 20.08         | 22.31         | 24.54         | 26.78           | 29.01         | 31.24         | 33.47         | 35.70         | 10             | 10                      |
| 2.34                              | 4.68          | 7.01           | 9.35          | 11.89          | 14.03         | 16.36          | 18.70         | 21.04         | 23.38         | 25.71         | 28.05           | 30.39         | 32.73         | 35.06         | 37.40         | 11             | 11                      |
| 2.44                              | 4.89          | 7.33           | 9.78          | 12.22          | 14.66         | 17.11          | 19.55         | 21.99         | 24.44         | 26.88         | 29.33           | 31.77         | 34.21         | 36.66         | 39.10         | 11             | 11                      |
| 2.55                              | 5.10          | 7.65           | 10.20         | 12.75          | 15.20         | 17.85          | 20.40         | 22.95         | 25.50         | 28.05         | 30.60           | 33.15         | 35.70         | 38.25         | 40.80         | 12             | 12                      |
| $\frac{1}{16}$                    | $\frac{1}{8}$ | $\frac{3}{16}$ | $\frac{1}{4}$ | $\frac{5}{16}$ | $\frac{3}{8}$ | $\frac{7}{16}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | $\frac{3}{4}$ | $\frac{7}{8}$ | $\frac{15}{16}$ | $\frac{1}{2}$ | $\frac{3}{4}$ | $\frac{1}{2}$ | $\frac{1}{4}$ | 1 in.          | Breadth of Plate (ins.) |

Thickness in Fractions of an Inch

TABLE OF THE WEIGHT OF ANGLE STEEL IN LBS. PER LINEAL FOOT.

| Thickness in Fractions of an Inch |                |                |                |                |                |                |                |                |                |                 |                 |                 |                 |                 | Sum of<br>Flanges<br>(ins.) |  |
|-----------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------------------|--|
| $\frac{1}{16}$                    | $\frac{1}{8}$  | $\frac{3}{16}$ | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{5}{8}$  | $\frac{11}{16}$ | $\frac{3}{4}$   | $\frac{13}{16}$ | $\frac{7}{8}$   |                 | Sum of<br>Flanges<br>(ins.) |  |
| 1                                 | .199           | .372           | .518           | —              | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1               | 1                           |  |
| 1 $\frac{1}{4}$                   | .252           | .478           | .677           | —              | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1 $\frac{1}{4}$ | 1 $\frac{1}{4}$             |  |
| 1 $\frac{1}{2}$                   | .305           | .584           | .837           | 1.26           | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1 $\frac{1}{2}$ | 1 $\frac{1}{2}$             |  |
| 1 $\frac{3}{4}$                   | .359           | .691           | .996           | 1.53           | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1 $\frac{3}{4}$ | 1 $\frac{3}{4}$             |  |
| 2                                 | .412           | .797           | 1.155          | 1.79           | 2.07           | —              | —              | —              | —              | —               | —               | —               | —               | 2               | 2                           |  |
| 2 $\frac{1}{4}$                   | .465           | .903           | 1.315          | 2.06           | 2.39           | —              | —              | —              | —              | —               | —               | —               | —               | 2 $\frac{1}{4}$ | 2 $\frac{1}{4}$             |  |
| 2 $\frac{1}{2}$                   | .518           | 1.009          | 1.474          | 2.32           | 2.71           | 3.07           | —              | —              | —              | —               | —               | —               | —               | 2 $\frac{1}{2}$ | 2 $\frac{1}{2}$             |  |
| 2 $\frac{3}{4}$                   | .571           | 1.116          | 1.634          | 2.59           | 3.03           | 3.44           | —              | —              | —              | —               | —               | —               | —               | 2 $\frac{3}{4}$ | 2 $\frac{3}{4}$             |  |
| 3                                 | .624           | 1.222          | 1.793          | 2.86           | 3.35           | 3.81           | 4.25           | —              | —              | —               | —               | —               | —               | 3               | 3                           |  |
| 3 $\frac{1}{4}$                   | .677           | 1.328          | 1.952          | 3.12           | 3.67           | 4.18           | 4.68           | —              | —              | —               | —               | —               | —               | 3 $\frac{1}{4}$ | 3 $\frac{1}{4}$             |  |
| 3 $\frac{1}{2}$                   | .730           | 1.434          | 2.112          | 3.39           | 3.98           | 4.56           | 5.10           | 5.62           | —              | —               | —               | —               | —               | 3 $\frac{1}{2}$ | 3 $\frac{1}{2}$             |  |
| 3 $\frac{3}{4}$                   | .784           | 1.541          | 2.271          | 3.65           | 4.30           | 4.93           | 5.53           | 6.10           | —              | —               | —               | —               | —               | 3 $\frac{3}{4}$ | 3 $\frac{3}{4}$             |  |
| 4                                 | .837           | 1.647          | 2.430          | 3.92           | 4.62           | 5.30           | 5.95           | 6.57           | 7.17           | —               | —               | —               | —               | 4               | 4                           |  |
| 4 $\frac{1}{4}$                   | .890           | 1.753          | 2.590          | 4.18           | 4.94           | 5.67           | 6.38           | 7.05           | 7.70           | —               | —               | —               | —               | 4 $\frac{1}{4}$ | 4 $\frac{1}{4}$             |  |
| 4 $\frac{1}{2}$                   | .943           | 1.859          | 2.749          | 4.45           | 5.26           | 6.04           | 6.80           | 7.53           | 8.23           | 8.91            | —               | —               | —               | 4 $\frac{1}{2}$ | 4 $\frac{1}{2}$             |  |
| 4 $\frac{3}{4}$                   | .996           | 1.966          | 2.909          | 4.71           | 5.58           | 6.41           | 7.23           | 8.01           | 8.77           | 9.50            | —               | —               | —               | 4 $\frac{3}{4}$ | 4 $\frac{3}{4}$             |  |
| 5                                 | 1.049          | 2.072          | 3.068          | 4.98           | 5.90           | 6.79           | 7.65           | 8.49           | 9.30           | 10.08           | 10.84           | —               | —               | 5               | 5                           |  |
| 5 $\frac{1}{4}$                   | 1.102          | 2.178          | 3.228          | 5.25           | 6.22           | 7.16           | 8.08           | 8.96           | 9.83           | 10.66           | 11.48           | 12.26           | —               | 5 $\frac{1}{4}$ | 5 $\frac{1}{4}$             |  |
| 5 $\frac{1}{2}$                   | 1.155          | 2.284          | 3.388          | 5.51           | 6.53           | 7.53           | 8.50           | 9.44           | 10.36          | 11.25           | 12.11           | 12.95           | 13.76           | 5 $\frac{1}{2}$ | 5 $\frac{1}{2}$             |  |
| 5 $\frac{3}{4}$                   | 1.209          | 2.391          | 3.546          | 5.78           | 6.85           | 7.90           | 8.93           | 9.92           | 10.89          | 11.83           | 12.75           | 13.64           | 14.50           | 5 $\frac{3}{4}$ | 5 $\frac{3}{4}$             |  |
| Sum of<br>Flanges<br>(ins.)       | $\frac{1}{16}$ | $\frac{1}{8}$  | $\frac{3}{16}$ | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{5}{8}$   | $\frac{11}{16}$ | $\frac{3}{4}$   | $\frac{13}{16}$ | $\frac{7}{8}$   | Sum of<br>Flanges<br>(ins.) |  |

| Thickness in Fractions of an Inch |                |                |                |                |                |                |                |                |                |                 |                 |                 |                 |                 | Sum of<br>Flanges<br>(ins.) |  |
|-----------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------------------|--|
| $\frac{1}{16}$                    | $\frac{1}{8}$  | $\frac{3}{16}$ | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{5}{8}$  | $\frac{11}{16}$ | $\frac{3}{4}$   | $\frac{13}{16}$ | $\frac{7}{8}$   |                 | Sum of<br>Flanges<br>(ins.) |  |
| 1                                 | .199           | .372           | .518           | —              | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1               | 1                           |  |
| 1 $\frac{1}{4}$                   | .252           | .478           | .677           | —              | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1 $\frac{1}{4}$ | 1 $\frac{1}{4}$             |  |
| 1 $\frac{1}{2}$                   | .305           | .584           | .837           | 1.26           | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1 $\frac{1}{2}$ | 1 $\frac{1}{2}$             |  |
| 1 $\frac{3}{4}$                   | .359           | .691           | .996           | 1.53           | —              | —              | —              | —              | —              | —               | —               | —               | —               | 1 $\frac{3}{4}$ | 1 $\frac{3}{4}$             |  |
| 2                                 | .412           | .797           | 1.155          | 1.79           | 2.07           | —              | —              | —              | —              | —               | —               | —               | —               | 2               | 2                           |  |
| 2 $\frac{1}{4}$                   | .465           | .903           | 1.315          | 2.06           | 2.39           | —              | —              | —              | —              | —               | —               | —               | —               | 2 $\frac{1}{4}$ | 2 $\frac{1}{4}$             |  |
| 2 $\frac{1}{2}$                   | .518           | 1.009          | 1.474          | 2.32           | 2.71           | 3.07           | —              | —              | —              | —               | —               | —               | —               | 2 $\frac{1}{2}$ | 2 $\frac{1}{2}$             |  |
| 2 $\frac{3}{4}$                   | .571           | 1.116          | 1.634          | 2.59           | 3.03           | 3.44           | —              | —              | —              | —               | —               | —               | —               | 2 $\frac{3}{4}$ | 2 $\frac{3}{4}$             |  |
| 3                                 | .624           | 1.222          | 1.793          | 2.86           | 3.35           | 3.81           | 4.25           | —              | —              | —               | —               | —               | —               | 3               | 3                           |  |
| 3 $\frac{1}{4}$                   | .677           | 1.328          | 1.952          | 3.12           | 3.67           | 4.18           | 4.68           | 5.62           | —              | —               | —               | —               | —               | 3 $\frac{1}{4}$ | 3 $\frac{1}{4}$             |  |
| 3 $\frac{1}{2}$                   | .730           | 1.434          | 2.112          | 3.39           | 3.98           | 4.56           | 5.10           | 6.10           | —              | —               | —               | —               | —               | 3 $\frac{1}{2}$ | 3 $\frac{1}{2}$             |  |
| 3 $\frac{3}{4}$                   | .784           | 1.541          | 2.271          | 3.65           | 4.30           | 4.93           | 5.53           | 6.57           | 7.17           | —               | —               | —               | —               | 3 $\frac{3}{4}$ | 3 $\frac{3}{4}$             |  |
| 4                                 | .837           | 1.647          | 2.430          | 3.92           | 4.62           | 5.30           | 5.95           | 6.57           | 7.70           | —               | —               | —               | —               | 4               | 4                           |  |
| 4 $\frac{1}{4}$                   | .890           | 1.753          | 2.590          | 4.18           | 4.94           | 5.67           | 6.38           | 7.05           | 8.23           | 8.91            | —               | —               | —               | 4 $\frac{1}{4}$ | 4 $\frac{1}{4}$             |  |
| 4 $\frac{1}{2}$                   | .943           | 1.859          | 2.749          | 4.45           | 5.26           | 6.04           | 6.80           | 7.53           | 8.77           | 9.50            | —               | —               | —               | 4 $\frac{1}{2}$ | 4 $\frac{1}{2}$             |  |
| 4 $\frac{3}{4}$                   | .996           | 1.966          | 2.909          | 4.71           | 5.58           | 6.41           | 7.23           | 8.01           | 9.30           | 10.08           | 10.84           | —               | —               | 4 $\frac{3}{4}$ | 4 $\frac{3}{4}$             |  |
| 5                                 | 1.049          | 2.072          | 3.068          | 4.98           | 5.90           | 6.79           | 7.65           | 8.49           | 9.83           | 10.66           | 11.48           | 12.26           | —               | 5               | 5                           |  |
| 5 $\frac{1}{4}$                   | 1.102          | 2.178          | 3.228          | 5.25           | 6.22           | 7.16           | 8.08           | 8.96           | 10.36          | 11.25           | 12.11           | 12.95           | 13.76           | 5 $\frac{1}{4}$ | 5 $\frac{1}{4}$             |  |
| 5 $\frac{1}{2}$                   | 1.155          | 2.284          | 3.388          | 5.51           | 6.53           | 7.53           | 8.50           | 9.44           | 10.89          | 11.83           | 12.75           | 13.64           | 14.50           | 5 $\frac{1}{2}$ | 5 $\frac{1}{2}$             |  |
| 5 $\frac{3}{4}$                   | 1.209          | 2.391          | 3.546          | 5.78           | 6.85           | 7.90           | 8.93           | 9.92           | 10.89          | 11.83           | 12.75           | 13.64           | 14.50           | 5 $\frac{3}{4}$ | 5 $\frac{3}{4}$             |  |
| Sum of<br>Flanges<br>(ins.)       | $\frac{1}{16}$ | $\frac{1}{8}$  | $\frac{3}{16}$ | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{5}{8}$   | $\frac{11}{16}$ | $\frac{3}{4}$   | $\frac{13}{16}$ | $\frac{7}{8}$   | Sum of<br>Flanges<br>(ins.) |  |

TABLE OF THE WEIGHT OF ANGLE STEEL IN LBS. PER LINEAL FOOT (continued).

| Sum of<br>Flanges<br>(ins.) | Thickness in Fractions of an Inch |                 |                 |                 |                 |                 |                 |                |                 |                |                 |       | Sum of<br>Flanges<br>(ins.) |
|-----------------------------|-----------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|----------------|-----------------|-------|-----------------------------|
|                             | $\frac{1}{16}$                    | $\frac{1}{8}$   | $\frac{7}{16}$  | $\frac{1}{2}$   | $\frac{9}{16}$  | $\frac{5}{8}$   | $\frac{11}{16}$ | $\frac{3}{4}$  | $\frac{13}{16}$ | $\frac{7}{8}$  | $\frac{15}{16}$ | 1 in. |                             |
| 6                           | 3.71                              | 4.89            | 6.04            | 7.17            | 8.27            | 9.35            | 10.40           | 11.42          | 12.42           | 13.39          | 14.33           | 15.25 | 6                           |
| 6 $\frac{1}{8}$             | 3.86                              | 5.10            | 6.31            | 7.49            | 8.65            | 9.78            | 10.88           | 11.95          | 13.00           | 14.03          | 15.02           | 15.99 | 6 $\frac{1}{8}$             |
| 6 $\frac{1}{4}$             | 4.02                              | 5.31            | 6.57            | 7.81            | 9.02            | 10.20           | 11.36           | 12.48          | 13.59           | 14.66          | 15.71           | 16.73 | 6 $\frac{1}{4}$             |
| 6 $\frac{3}{8}$             | 4.18                              | 5.53            | 6.84            | 8.13            | 9.39            | 10.63           | 11.83           | 13.02          | 14.17           | 15.30          | 16.40           | 17.48 | 6 $\frac{3}{8}$             |
| 7                           | 4.34                              | 5.74            | 7.11            | 8.45            | 9.76            | 11.05           | 12.31           | 13.55          | 14.76           | 15.94          | 17.09           | 18.22 | 7                           |
| 7 $\frac{1}{8}$             | 4.50                              | 5.95            | 7.37            | 8.77            | 10.13           | 11.48           | 12.79           | 14.08          | 15.34           | 16.58          | 17.78           | 18.97 | 7 $\frac{1}{8}$             |
| 7 $\frac{1}{4}$             | 4.66                              | 6.16            | 7.64            | 9.08            | 10.51           | 11.90           | 13.27           | 14.61          | 15.92           | 17.21          | 18.47           | 19.71 | 7 $\frac{1}{4}$             |
| 7 $\frac{3}{8}$             | 4.83                              | 6.38            | 7.90            | 9.40            | 10.88           | 12.33           | 13.75           | 15.14          | 16.51           | 17.85          | 19.16           | 20.45 | 7 $\frac{3}{8}$             |
| 8                           | 4.98                              | 6.59            | 8.17            | 9.72            | 11.25           | 12.75           | 14.22           | 15.67          | 17.09           | 18.49          | 19.85           | 21.20 | 8                           |
| 8 $\frac{1}{8}$             | 5.14                              | 6.80            | 8.43            | 10.04           | 11.62           | 13.18           | 14.70           | 16.20          | 17.68           | 19.13          | 20.55           | 21.94 | 8 $\frac{1}{8}$             |
| 8 $\frac{1}{4}$             | 5.30                              | 7.01            | 8.70            | 10.36           | 11.99           | 13.60           | 15.16           | 16.73          | 18.26           | 19.76          | 21.24           | 22.68 | 8 $\frac{1}{4}$             |
| 8 $\frac{3}{8}$             | 5.46                              | 7.23            | 8.96            | 10.68           | 12.36           | 14.03           | 15.66           | 17.27          | 18.85           | 20.40          | 21.93           | 23.43 | 8 $\frac{3}{8}$             |
| 9                           | 5.62                              | 7.44            | 9.23            | 11.00           | 12.74           | 14.45           | 16.14           | 17.80          | 19.43           | 21.04          | 22.62           | 24.17 | 9                           |
| 9 $\frac{1}{8}$             | 5.78                              | 7.65            | 9.50            | 11.32           | 13.11           | 14.88           | 16.61           | 18.33          | 20.01           | 21.68          | 23.31           | 24.92 | 9 $\frac{1}{8}$             |
| 9 $\frac{1}{4}$             | 5.94                              | 7.86            | 9.76            | 11.63           | 13.48           | 15.30           | 17.09           | 18.86          | 20.60           | 22.31          | 24.00           | 25.66 | 9 $\frac{1}{4}$             |
| 9 $\frac{3}{8}$             | 6.10                              | 8.08            | 10.03           | 11.95           | 13.85           | 15.73           | 17.57           | 19.39          | 21.18           | 22.95          | 24.69           | 26.40 | 9 $\frac{3}{8}$             |
| 10                          | 6.26                              | 8.29            | 10.29           | 12.27           | 14.22           | 16.15           | 18.05           | 19.92          | 21.77           | 23.59          | 25.38           | 27.15 | 10                          |
| 10 $\frac{1}{8}$            | 6.41                              | 8.50            | 10.56           | 12.59           | 14.60           | 16.58           | 18.53           | 20.45          | 22.35           | 24.23          | 26.07           | 27.89 | 10 $\frac{1}{8}$            |
| 10 $\frac{1}{4}$            | 6.57                              | 8.71            | 10.82           | 12.91           | 14.97           | 17.00           | 19.01           | 20.98          | 22.94           | 24.86          | 26.76           | 28.63 | 10 $\frac{1}{4}$            |
| 10 $\frac{3}{8}$            | 6.73                              | 8.93            | 11.09           | 13.23           | 15.34           | 17.43           | 19.48           | 21.52          | 23.52           | 25.50          | 27.45           | 29.38 | 10 $\frac{3}{8}$            |
| Sum of<br>Flanges<br>(ins.) | 1 in.                             | $\frac{15}{16}$ | $\frac{14}{16}$ | $\frac{13}{16}$ | $\frac{12}{16}$ | $\frac{11}{16}$ | $\frac{10}{16}$ | $\frac{9}{16}$ | $\frac{8}{16}$  | $\frac{7}{16}$ | $\frac{6}{16}$  | 1 in. | Sum of<br>Flanges<br>(ins.) |

Thickness in Fractions of an Inch

TABLE OF THE WEIGHT OF ANGLE STEEL IN LBS. PER LINEAL FOOT (concluded).

| Thickness in Fractions of an Inch |                |                |                |                |                |                |                |                 |                 |                 |                 |                 |                 |                             | Sum of<br>Flanges<br>(ins.) |
|-----------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------------------|-----------------------------|
| $\frac{3}{16}$                    | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{5}{8}$  | $\frac{11}{16}$ | $\frac{3}{4}$   | $\frac{13}{16}$ | $\frac{7}{8}$   | $\frac{15}{16}$ | 1 in.           | Sum of<br>Flanges<br>(ins.) |                             |
| 6.89                              | 9.14           | 11.36          | 13.55          | 15.71          | 17.85          | 19.96          | 22.05          | 24.11           | 26.14           | 28.14           | 30.12           | 32.07           | 34.00           | 11                          |                             |
| 7.05                              | 9.35           | 11.62          | 13.87          | 16.08          | 18.28          | 20.44          | 22.58          | 24.69           | 26.78           | 28.83           | 30.87           | 32.87           | 34.85           | 11 $\frac{1}{4}$            |                             |
| 7.21                              | 9.56           | 11.89          | 14.18          | 16.46          | 18.70          | 20.92          | 23.11          | 25.27           | 27.41           | 29.52           | 31.61           | 33.67           | 35.70           | 11 $\frac{1}{2}$            |                             |
| 7.37                              | 9.78           | 12.15          | 14.50          | 16.83          | 19.13          | 21.40          | 23.64          | 25.86           | 28.06           | 30.21           | 32.35           | 34.46           | 36.55           | 11 $\frac{3}{4}$            |                             |
| 7.53                              | 9.99           | 12.42          | 14.82          | 17.20          | 19.55          | 21.87          | 24.17          | 26.44           | 28.69           | 30.91           | 33.10           | 35.26           | 37.40           | 12                          |                             |
| —                                 | 10.20          | 12.68          | 15.14          | 17.57          | 19.98          | 22.35          | 24.70          | 27.03           | 29.33           | 31.60           | 33.84           | 36.06           | 38.25           | 12 $\frac{1}{4}$            |                             |
| —                                 | 10.41          | 12.95          | 15.46          | 17.94          | 20.40          | 22.83          | 25.23          | 27.61           | 29.96           | 32.29           | 34.58           | 36.86           | 39.10           | 12 $\frac{1}{2}$            |                             |
| —                                 | 10.63          | 13.21          | 15.78          | 18.31          | 20.83          | 23.31          | 25.77          | 28.20           | 30.60           | 32.98           | 35.33           | 37.65           | 39.95           | 12 $\frac{3}{4}$            |                             |
| —                                 | 10.84          | 13.48          | 16.10          | 18.69          | 21.25          | 23.79          | 26.30          | 28.78           | 31.24           | 33.67           | 36.07           | 38.45           | 40.80           | 13                          |                             |
| —                                 | 11.05          | 13.75          | 16.42          | 19.06          | 21.68          | 24.26          | 26.83          | 29.36           | 31.88           | 34.36           | 36.82           | 39.25           | 41.65           | 13 $\frac{1}{4}$            |                             |
| —                                 | 11.26          | 14.01          | 16.73          | 19.43          | 22.10          | 24.74          | 27.36          | 29.95           | 32.51           | 35.05           | 37.56           | 40.04           | 42.50           | 13 $\frac{1}{2}$            |                             |
| —                                 | 11.48          | 14.28          | 17.05          | 19.80          | 22.53          | 25.22          | 27.89          | 30.53           | 33.15           | 35.74           | 38.30           | 40.84           | 43.35           | 13 $\frac{3}{4}$            |                             |
| —                                 | —              | 14.54          | 17.37          | 20.17          | 22.95          | 25.70          | 28.42          | 31.12           | 33.79           | 36.43           | 39.05           | 41.64           | 44.20           | 14                          |                             |
| —                                 | —              | 14.81          | 17.69          | 20.55          | 23.38          | 26.18          | 28.95          | 31.70           | 34.43           | 37.12           | 39.79           | 42.43           | 45.05           | 14 $\frac{1}{4}$            |                             |
| —                                 | —              | 15.07          | 18.01          | 20.92          | 23.80          | 26.66          | 29.48          | 32.29           | 35.06           | 37.81           | 40.53           | 43.23           | 45.90           | 14 $\frac{1}{2}$            |                             |
| —                                 | —              | 15.34          | 18.33          | 21.29          | 24.23          | 27.13          | 30.02          | 32.87           | 35.70           | 38.50           | 41.28           | 44.03           | 46.75           | 14 $\frac{3}{4}$            |                             |
| —                                 | —              | 15.61          | 18.65          | 21.66          | 24.65          | 27.61          | 30.55          | 33.46           | 36.34           | 39.19           | 42.02           | 44.82           | 47.60           | 15                          |                             |
| Sum of<br>Flanges<br>(ins.)       | $\frac{3}{16}$ | $\frac{1}{4}$  | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{7}{16}$ | $\frac{1}{2}$  | $\frac{9}{16}$ | $\frac{5}{8}$   | $\frac{11}{16}$ | $\frac{3}{4}$   | $\frac{13}{16}$ | $\frac{7}{8}$   | $\frac{15}{16}$ | 1 in.                       | Sum of<br>Flanges<br>(ins.) |

Thickness in Fractions of an Inch

RULE.—To Calculate the Weight of Angle Bars :—  
 $w$  = weight of metal in lbs. per square foot of  $t$  thickness.  
 $f$  = thickness of angle bar in decimals of a foot.  
 $W = (s - f)w$ .  
 $w$  = weight of angle bar in lbs. per lineal foot.  
 $s$  = sum of breadth of flanges in decimals of a foot.  
 $W = (s - f)w$ .

TABLE OF THE WEIGHT OF ROUND AND SQUARE BAR STEEL  
IN LBS. PER LINEAL FOOT.

| Width<br>in Ins. | Weight in Lbs. |        | Width<br>in Ins. | Weight in Lbs. |        | Width<br>in Ins. | Weight in Lbs. |        |
|------------------|----------------|--------|------------------|----------------|--------|------------------|----------------|--------|
|                  | Round          | Square |                  | Round          | Square |                  | Round          | Square |
| 1/8              | .042           | .053   | 3                | 35.090         | 44.678 | 7 1/2            | 165.60         | 210.85 |
|                  | .094           | .120   |                  | 37.552         | 47.813 |                  | 170.90         | 217.60 |
|                  | .167           | .213   |                  | 40.097         | 51.053 |                  | 176.29         | 225.25 |
|                  | .261           | .332   |                  |                |        |                  | 181.75         | 231.41 |
|                  | .375           | .478   |                  | 42.726         | 54.400 |                  | 187.30         | 238.48 |
|                  | .511           | .651   |                  | 45.438         | 57.853 |                  | 192.93         | 245.65 |
|                  | .667           | .850   |                  | 48.233         | 61.413 |                  | 198.63         | 252.98 |
|                  | .845           | 1.076  |                  | 51.112         | 65.078 |                  | 204.45         | 260.31 |
|                  | 1.043          | 1.328  |                  | 54.075         | 68.850 |                  | 210.33         | 267.80 |
|                  | 1.262          | 1.607  |                  | 57.121         | 72.728 | 9                | 216.30         | 275.40 |
|                  | 1.502          | 1.913  |                  | 60.250         | 76.713 |                  | 222.35         | 283.10 |
|                  | 1.762          | 2.245  |                  | 63.463         | 80.803 |                  | 228.48         | 290.91 |
|                  | 2.044          | 2.603  |                  |                |        |                  | 234.70         | 298.83 |
|                  | 2.347          | 2.988  |                  |                |        |                  | 241.00         | 306.85 |
| 1                |                |        | 5                | 66.759         | 85.000 |                  | 248.38         | 314.98 |
|                  |                |        |                  | 70.139         | 89.303 |                  | 253.85         | 323.21 |
|                  | 2.670          | 3.400  |                  | 73.602         | 93.713 |                  | 260.40         | 331.55 |
|                  | 3.880          | 4.903  |                  | 77.148         | 98.229 | 10               | 267.04         | 340.00 |
|                  | 4.172          | 5.313  |                  | 80.778         | 102.85 |                  | 273.75         | 348.55 |
|                  | 5.049          | 6.428  |                  | 84.492         | 107.58 |                  | 280.55         | 357.21 |
|                  | 6.008          | 7.650  |                  | 88.288         | 112.41 |                  | 287.44         | 365.98 |
|                  | 7.051          | 8.978  |                  | 92.169         | 117.35 |                  | 294.41         | 374.85 |
|                  | 8.178          | 10.413 |                  |                |        |                  | 301.46         | 383.83 |
|                  | 9.388          | 11.953 |                  |                |        |                  | 308.59         | 392.91 |
| 2                |                |        | 6                | 96.133         | 122.40 |                  | 315.81         | 402.10 |
|                  |                |        |                  | 100.18         | 127.55 | 11               | 323.11         | 411.40 |
|                  | 10.681         | 13.600 |                  | 104.31         | 132.81 |                  | 330.50         | 420.80 |
|                  | 12.058         | 15.353 |                  | 108.52         | 138.18 |                  | 337.97         | 430.31 |
|                  | 13.519         | 17.213 |                  | 112.82         | 143.65 |                  | 345.52         | 439.98 |
|                  | 15.062         | 19.178 |                  | 117.20         | 149.23 |                  | 353.15         | 449.65 |
|                  | 16.690         | 21.250 |                  | 121.67         | 154.91 |                  | 360.87         | 459.48 |
|                  | 18.400         | 23.428 |                  | 126.23         | 160.70 |                  | 368.68         | 469.41 |
|                  | 20.195         | 25.713 |                  |                |        |                  | 376.56         | 479.45 |
|                  | 22.072         | 28.103 |                  |                |        |                  | 384.53         | 489.60 |
| 3                |                |        | 7                | 130.85         | 166.60 | 12               |                |        |
|                  |                |        |                  | 135.56         | 172.60 |                  |                |        |
|                  | 24.033         | 30.600 |                  | 140.36         | 178.71 |                  |                |        |
|                  | 26.078         | 33.203 |                  | 145.24         | 184.93 |                  |                |        |
|                  | 28.206         | 35.913 |                  | 150.21         | 191.25 |                  |                |        |
|                  | 30.417         | 38.728 |                  | 155.25         | 197.68 |                  |                |        |
|                  | 32.712         | 41.650 |                  | 160.39         | 204.21 |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
|                  |                |        |                  |                |        |                  |                |        |
| Width<br>in Ins. | Weight in Lbs. |        | Width<br>in Ins. | Weight in Lbs. |        | Width<br>in Ins. | Weight in Lbs. |        |
|                  | Round          | Square |                  | Round          | Square |                  | Round          | Square |

TABLE OF THE WEIGHT OF MALLEABLE IRON PIPES IN  
LBS. PER LINEAL FOOT.

| Diam.<br>(Inch.) | Thickness in Inches |       |        |       |        |        |        |        |        | Diam.<br>(Inch.) |
|------------------|---------------------|-------|--------|-------|--------|--------|--------|--------|--------|------------------|
|                  | 1/4                 | 3/8   | 1/2    | 5/8   | 3/4    | 7/8    | 1      | 1 1/8  | 1 1/4  |                  |
| 1                | 8-27                | 5-40  | 7-05   | 10-13 | —      | —      | —      | —      | —      | 1                |
| 1 1/4            | 8-98                | 6-38  | 9-16   | 12-27 | 15-71  | —      | —      | —      | —      | 1 1/4            |
| 1 1/2            | 4-58                | 7-36  | 10-47  | 13-91 | 17-67  | 21-76  | —      | —      | —      | 1 1/2            |
| 1 3/4            | 5-24                | 8-34  | 11-78  | 15-54 | 19-68  | 24-06  | 28-40  | —      | —      | 1 3/4            |
| 2                | 6-09                | 9-33  | 13-07  | 17-18 | 21-60  | 26-34  | 31-41  | 36-01  | —      | 2                |
| 2 1/4            | 6-55                | 10-51 | 14-40  | 18-02 | 23-56  | 28-63  | 34-08  | 39-76  | 45-01  | 2 1/4            |
| 2 1/2            | 7-20                | 11-29 | 15-71  | 20-45 | 25-52  | 30-92  | 36-65  | 42-70  | 49-08  | 2 1/2            |
| 2 3/4            | 7-85                | 12-27 | 16-102 | 22-09 | 27-49  | 33-21  | 39-27  | 45-68  | 52-35  | 2 3/4            |
| 3                | 8-51                | 13-25 | 18-32  | 23-72 | 29-45  | 35-50  | 41-98  | 48-59  | 55-63  | 3                |
| 3 1/4            | 9-16                | 14-23 | 19-63  | 25-36 | 31-41  | 37-79  | 45-50  | 51-54  | 58-90  | 3 1/4            |
| 3 1/2            | 9-82                | 15-22 | 20-94  | 27-00 | 33-88  | 40-08  | 47-12  | 54-48  | 62-17  | 3 1/2            |
| 3 3/4            | 10-47               | 16-20 | 22-25  | 28-63 | 35-84  | 42-87  | 49-74  | 57-48  | 65-45  | 3 3/4            |
| 4                | 11-13               | 17-18 | 23-56  | 30-27 | 37-80  | 44-67  | 52-85  | 60-88  | 68-72  | 4                |
| 4 1/4            | 11-78               | 18-16 | 24-87  | 31-90 | 39-27  | 46-96  | 54-48  | 63-82  | 71-99  | 4 1/4            |
| 4 1/2            | 12-43               | 19-14 | 26-18  | 33-51 | 41-23  | 49-25  | 57-59  | 66-28  | 75-26  | 4 1/2            |
| 4 3/4            | 13-09               | 20-12 | 27-49  | 35-18 | 43-20  | 51-54  | 60-21  | 69-21  | 78-64  | 4 3/4            |
| 5                | 13-74               | 21-11 | 28-80  | 36-82 | 45-16  | 53-88  | 62-88  | 72-16  | 81-8   | 5                |
| 5 1/4            | 14-40               | 22-09 | 30-11  | 38-45 | 47-12  | 56-12  | 65-45  | 75-10  | 85-08  | 5 1/4            |
| 5 1/2            | 15-01               | 23-08 | 31-41  | 40-08 | 49-08  | 58-41  | 68-06  | 78-04  | 88-64  | 5 1/2            |
| 5 3/4            | 15-71               | 24-05 | 32-72  | 41-72 | 51-05  | 60-70  | 70-68  | 80-98  | 91-82  | 5 3/4            |
| 6                | 16-36               | 25-03 | 34-03  | 43-86 | 53-01  | 62-90  | 73-29  | 83-98  | 94-09  | 6                |
| 6 1/4            | 17-00               | 26-01 | 35-34  | 44-99 | 54-97  | 65-27  | 75-81  | 86-87  | 98-16  | 6 1/4            |
| 6 1/2            | 17-67               | 27-00 | 36-65  | 46-63 | 56-93  | 67-57  | 78-58  | 89-82  | 101-44 | 6 1/2            |
| 6 3/4            | 18-33               | 27-98 | 37-96  | 48-26 | 58-90  | 69-86  | 81-15  | 92-77  | 104-51 | 6 3/4            |
| 7                | 18-98               | 28-96 | 39-26  | 49-90 | 60-88  | 72-15  | 83-77  | 95-71  | 107-98 | 7                |
| 7 1/4            | 19-63               | 29-93 | 40-57  | 51-53 | 62-82  | 74-44  | 86-38  | 98-65  | 111-25 | 7 1/4            |
| 7 1/2            | 20-28               | 30-92 | 41-88  | 53-17 | 64-79  | 76-78  | 88-90  | 101-60 | 114-63 | 7 1/2            |
| 7 3/4            | 20-94               | 31-90 | 43-19  | 54-81 | 66-75  | 79-02  | 91-62  | 104-24 | 117-80 | 7 3/4            |
| 8                | 21-60               | 32-89 | 44-51  | 56-45 | 68-72  | 81-82  | 94-24  | 107-50 | 121-07 | 8                |
| 8 1/4            | 22-25               | 33-87 | 45-81  | 58-08 | 70-68  | 83-60  | 96-86  | 110-48 | 124-84 | 8 1/4            |
| 8 1/2            | 22-91               | 34-85 | 47-12  | 59-72 | 72-64  | 85-90  | 99-47  | 113-88 | 127-62 | 8 1/2            |
| 8 3/4            | 23-56               | 35-83 | 48-43  | 61-35 | 74-61  | 88-18  | 102-29 | 116-88 | 130-89 | 8 3/4            |
| 9                | 24-21               | 36-81 | 49-73  | 62-98 | 76-56  | 90-47  | 104-71 | 119-27 | 134-16 | 9                |
| 9 1/4            | 24-87               | 37-79 | 51-05  | 64-62 | 78-53  | 92-77  | 107-88 | 122-22 | 137-43 | 9 1/4            |
| 9 1/2            | 25-52               | 38-78 | 52-35  | 66-26 | 80-50  | 95-06  | 109-95 | 125-16 | 140-70 | 9 1/2            |
| 9 3/4            | 26-18               | 39-75 | 53-66  | 67-90 | 82-48  | 97-85  | 112-58 | 128-10 | 143-97 | 9 3/4            |
| 10               | 26-83               | 40-74 | 54-98  | 69-54 | 84-48  | 99-64  | 115-18 | 130-05 | 147-25 | 10               |
| 10 1/4           | 27-48               | 41-72 | 56-29  | 71-17 | 86-38  | 101-92 | 117-79 | 133-99 | 150-52 | 10 1/4           |
| 10 1/2           | 28-15               | 42-71 | 57-60  | 72-81 | 88-35  | 104-22 | 120-42 | 136-93 | 153-80 | 10 1/2           |
| 10 3/4           | 28-80               | 43-69 | 58-90  | 74-44 | 90-31  | 106-51 | 123-04 | 139-89 | 157-07 | 10 3/4           |
| 11               | 29-45               | 44-68 | 60-20  | 76-07 | 92-27  | 108-80 | 125-65 | 142-83 | 160-33 | 11               |
| 11 1/4           | 30-10               | 45-66 | 61-52  | 77-85 | 94-20  | 110-38 | 128-08 | 145-95 | 163-66 | 11 1/4           |
| 11 1/2           | 30-75               | 46-62 | 62-82  | 79-35 | 96-20  | 112-38 | 130-88 | 147-95 | 166-88 | 11 1/2           |
| 11 3/4           | 31-40               | 47-60 | 64-15  | 81-13 | 98-18  | 114-68 | 133-13 | 150-41 | 169-42 | 11 3/4           |
| 12               | 32-07               | 48-60 | 65-45  | 82-68 | 100-18 | 117-15 | 136-13 | 154-61 | 173-42 | 12               |
| Diam.<br>(Inch.) | Thickness in Inches |       |        |       |        |        |        |        |        | Diam.<br>(Inch.) |
|                  | 1/4                 | 3/8   | 1/2    | 5/8   | 3/4    | 7/8    | 1      | 1 1/8  | 1 1/4  |                  |



TABLE OF THE WEIGHT OF CAST-IRON PIPES IN LBS.  
PER LINEAL FOOT.

| Bore<br>(ins.)      | Thickness in inches |               |               |               |               |       |                 |                 | Bore<br>(ins.) |
|---------------------|---------------------|---------------|---------------|---------------|---------------|-------|-----------------|-----------------|----------------|
|                     | $\frac{1}{8}$       | $\frac{1}{4}$ | $\frac{3}{8}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | 1     | 1 $\frac{1}{2}$ | 1 $\frac{3}{4}$ |                |
| 1                   | 3-06                | 5-06          | 7-36          | 9-97          | —             | —     | —               | —               | 1              |
| $\frac{1}{2}$       | 3-69                | 5-98          | 8-59          | 11-51         | 14-78         | —     | —               | —               | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 4-29                | 6-90          | 9-82          | 13-04         | 16-56         | 20-4  | —               | —               | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 4-91                | 7-83          | 11-05         | 14-57         | 18-41         | 22-55 | 27-00           | —               | $\frac{1}{2}$  |
| 2                   | 5-53                | 8-75          | 12-27         | 16-11         | 20-25         | 24-7  | 29-45           | 34-46           | 2              |
| $\frac{1}{2}$       | 6-14                | 9-66          | 13-50         | 17-64         | 22-09         | 26-81 | 31-85           | 37-29           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 6-74                | 10-58         | 14-72         | 19-17         | 23-92         | 28-93 | 34-36           | 40-03           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 7-36                | 11-50         | 15-95         | 20-70         | 25-71         | 31-14 | 36-81           | 42-60           | $\frac{1}{2}$  |
| 3                   | 7-98                | 12-43         | 17-18         | 22-19         | 27-62         | 33-29 | 39-28           | 45-56           | 3              |
| $\frac{1}{2}$       | 8-59                | 13-84         | 18-35         | 23-78         | 29-45         | 35-44 | 41-72           | 48-32           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 9-20                | 14-21         | 19-64         | 25-31         | 31-30         | 37-58 | 44-18           | 51-08           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 9-76                | 15-19         | 20-46         | 26-85         | 33-13         | 39-73 | 46-68           | 53-84           | $\frac{1}{2}$  |
| 4                   | 10-44               | 16-11         | 22-10         | 28-38         | 34-98         | 41-68 | 49-09           | 56-61           | 4              |
| $\frac{1}{2}$       | 11-10               | 17-08         | 23-37         | 29-97         | 36-87         | 44-08 | 51-60           | 59-42           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 11-66               | 17-94         | 24-54         | 31-44         | 38-65         | 46-17 | 53-99           | 62-12           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 12-27               | 18-87         | 25-77         | 32-98         | 40-50         | 48-32 | 56-45           | 64-89           | $\frac{1}{2}$  |
| 5                   | 12-88               | 19-78         | 26-99         | 34-51         | 42-33         | 50-46 | 58-90           | 67-64           | 5              |
| $\frac{1}{2}$       | 13-50               | 20-71         | 28-23         | 36-05         | 44-18         | 52-62 | 61-38           | 70-41           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 14-11               | 21-63         | 29-45         | 37-58         | 46-02         | 54-76 | 63-81           | 73-17           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 14-73               | 22-55         | 30-68         | 39-12         | 47-86         | 56-91 | 66-27           | 75-94           | $\frac{1}{2}$  |
| 6                   | 15-34               | 23-47         | 31-91         | 40-65         | 49-70         | 59-06 | 68-78           | 78-70           | 6              |
| $\frac{1}{2}$       | 15-95               | 24-39         | 33-13         | 42-18         | 51-54         | 61-21 | 71-18           | 81-23           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 16-57               | 25-31         | 34-36         | 43-72         | 53-39         | 63-86 | 73-41           | 84-22           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 17-18               | 26-23         | 35-59         | 45-26         | 55-23         | 65-28 | 76-09           | 86-97           | $\frac{1}{2}$  |
| 7                   | 17-79               | 27-15         | 36-82         | 46-79         | 56-84         | 67-65 | 78-53           | 89-74           | 7              |
| $\frac{1}{2}$       | 18-41               | 28-08         | 38-05         | 48-10         | 58-91         | 69-79 | 81-00           | 92-50           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 19-03               | 29-00         | 39-05         | 49-88         | 60-74         | 71-95 | 83-45           | 95-26           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 19-64               | 29-69         | 40-50         | 51-38         | 62-59         | 74-09 | 85-90           | 98-02           | $\frac{1}{2}$  |
| 8                   | 20-25               | 30-33         | 41-71         | 52-92         | 64-42         | 76-23 | 88-35           | 100-8           | 8              |
| $\frac{1}{2}$       | 20-86               | 31-74         | 42-95         | 54-45         | 66-26         | 78-38 | 90-81           | 103-5           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 21-49               | 32-90         | 44-40         | 56-21         | 68-33         | 80-76 | 93-49           | 106-5           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 22-09               | 33-59         | 45-40         | 57-52         | 69-95         | 82-68 | 95-72           | 109-1           | $\frac{1}{2}$  |
| 9                   | 22-71               | 34-52         | 46-64         | 59-07         | 71-80         | 84-84 | 98-18           | 111-8           | 9              |
| $\frac{1}{2}$       | 23-31               | 35-43         | 47-88         | 60-59         | 73-63         | 86-97 | 100-6           | 114-6           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 23-93               | 36-36         | 49-09         | 62-13         | 75-47         | 89-13 | 103-1           | 117-4           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 24-55               | 37-28         | 50-32         | 63-66         | 77-32         | 91-28 | 105-5           | 120-1           | $\frac{1}{2}$  |
| 10                  | 25-16               | 38-20         | 51-54         | 65-20         | 79-16         | 93-42 | 108-0           | 122-9           | 10             |
| $\frac{1}{2}$       | 25-77               | 39-11         | 52-77         | 66-78         | 80-99         | 95-57 | 110-4           | 125-6           | $\frac{1}{2}$  |
| $\frac{3}{4}$       | 26-38               | 40-04         | 54-00         | 68-26         | 82-81         | 97-71 | 112-9           | 128-4           | $\frac{3}{4}$  |
| $\frac{1}{2}$       | 27-00               | 40-96         | 55-22         | 69-80         | 84-67         | 99-86 | 115-4           | 131-2           | $\frac{1}{2}$  |
| 11                  | 27-62               | 41-88         | 56-46         | 71-33         | 86-52         | 102-0 | 117-8           | 133-9           | 11             |
| $\frac{1}{2}$       | 28-24               | 43-71         | 58-90         | 74-39         | 90-19         | 106-3 | 122-7           | 139-4           | $\frac{1}{2}$  |
| 12                  | 30-06               | 45-55         | 61-35         | 77-46         | 93-60         | 110-6 | 127-6           | 145-0           | 12             |
| Bore<br>(ins.)      | $\frac{1}{8}$       | $\frac{1}{4}$ | $\frac{3}{8}$ | $\frac{1}{2}$ | $\frac{5}{8}$ | 1     | 1 $\frac{1}{2}$ | 1 $\frac{3}{4}$ | Bore<br>(ins.) |
| Thickness in inches |                     |               |               |               |               |       |                 |                 |                |

TABLE OF THE WEIGHTS OF MESSRS. JAMES TAYLOR AND CO.'S  
STEAM WINCHES AND CRANES.

|  |    |      |      |    |    |      |
|--|----|------|------|----|----|------|
| Steam winch to lift, in tons . . . . .               | 1½ | 2    | 2½   | 3  | 5  | 6    |
| Diameter of cylinder in ins. . . . .                 | 5  | 5    | 6    | 7  | 8  | 9    |
| Length of stroke in ins. . . . .                     | 8  | 10   | 10   | 12 | 12 | 12   |
| Weight in cwts. . . . .                              | 21 | 34.5 | 35.5 | 52 | 57 | 88.5 |
| Steam crane to lift, in tons . . . . .               |    | 2    | 2½   | 3  | 4  |      |
| Weight with pillar to 'tween decks, in cwts. . . . . |    | 73   | 75   | 80 | 84 |      |

TABLE OF THE WEIGHTS OF SHIPS' GALLEYS.

|                           |     |     |     |     |     |     |     |     |     |
|---------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| No. to cook for . . . . . | 12  | 25  | 35  | 50  | 60  | 70  | 90  | 100 | 125 |
| Weight in cwts. . . . .   | 9   | 11  | 16  | 20  | 25  | 26  | 32  | 42  | 44  |
| No. to cook for . . . . . | 150 | 220 | 250 | 300 | 400 | 450 | 500 | 600 | 650 |
| Weight in cwts. . . . .   | 47  | 56  | 66  | 75  | 82  | 102 | 113 | 120 | 135 |

TABLE OF THE WEIGHTS OF DOUBLE AND SINGLE PUR-  
CHASE CRABS.

| SINGLE PURCHASE |         |                   |      |      | DOUBLE PURCHASE |         |                   |      |      |
|-----------------|---------|-------------------|------|------|-----------------|---------|-------------------|------|------|
| No.             | To Lift | Weight with Break |      |      | No.             | To Lift | Weight with Break |      |      |
|                 | Tons    | Cwts.             | Qrs. | Lbs. |                 | Tons    | Cwts.             | Qrs. | Lbs. |
| 1               | 1       | 2                 | 0    | 14   | 10              | 9       | 3                 | 1    | 12   |
| 2               | 1½      | 2                 | 1    | 16   | 11              | 3       | 3                 | 3    | 14   |
| 3               | 2       | 3                 | 0    | 0    | 12              | 4       | 5                 | 1    | 22   |
| 4               | 3       | 3                 | 2    | 12   | 13              | 6       | 6                 | 2    | ■    |
| 5               | 4       | 4                 | 3    | 15   | 14              | 8       | 7                 | 3    | 0    |
| 6               | 6       | 5                 | 3    | 16   | 15              | 10      | 9                 | 3    | 18   |
| —               | —       | —                 | —    | —    | 16              | 11      | 11                | 3    | 20   |
| —               | —       | —                 | —    | —    | 17              | 16      | 16                | 0    | 0    |

TABLE OF THE WEIGHT OF A CUBIC FOOT AND CUBIC INCH  
OF VARIOUS METALS.

|                  | C.<br>Iron | W<br>Iron | C.<br>Copper | S.<br>Copper | C.<br>Brass | S.<br>Brass | S.<br>Steel | S.<br>Steel |
|------------------|------------|-----------|--------------|--------------|-------------|-------------|-------------|-------------|
| Cub. ft. in ozs. | 7.271      | 7.680     | 8.788        | 8.915        | 8.396       | 8.525       | 7.818       | 7.833       |
| Cub. ft. in lbs. | 454.4      | 480.0     | 549.25       | 557.19       | 524.76      | 532.8       | 488.6       | 489.6       |
| Cub. in. in ozs. | 4.208      | 4.444     | 5.086        | 5.159        | 4.859       | 5.333       | 4.524       | 4.533       |
| Cub. in. in lbs. | .263       | .2777     | .3177        | .3225        | .3037       | .3088       | .2828       | .2833       |

TABLE OF THE WEIGHT OF LEAD PIPE IN LBS. PER LINEAL FOOT, AND LENGTHS IN WHICH IT IS USUALLY MANUFACTURED.

| Length (ft.) | Bore (ins.) | Weight per Foot in Lbs. |      |      |      |      |      |      |    | Length (ft.) | Bore (ins.) | Wght. per Ft. in Lbs. |      |      |   |
|--------------|-------------|-------------------------|------|------|------|------|------|------|----|--------------|-------------|-----------------------|------|------|---|
| 15           | 1           | 932                     | 1-07 | 1-2  | 1-47 | 1-73 | 1-87 | 2-33 | 12 | 3            | 9-0         | —                     | —    | —    | — |
|              |             | 1-2                     | 1-47 | 1-67 | 1-80 | —    | —    | —    | 10 | 2 1/2        | 13-0        | —                     | —    | —    | — |
|              |             | 1-47                    | 1-60 | 1-73 | 1-87 | 2-12 | 2-4  | 3-06 |    | 2 1/4        | 9-6         | 10-5                  | 12-0 | —    | — |
|              |             | 1                       | 1-87 | 2-4  | 2-8  | 3-00 | 3-60 | 3-93 |    | 3            | 11-8        | 12-0                  | 13-4 | 15-0 | — |
|              |             | 1 1/4                   | 3-00 | 3-17 | 3-50 | 4-33 | 5-08 | 5-25 |    | 3 1/2        | 13-5        | 15-0                  | 16-6 | 18-4 | — |
| 12           | 1           | 3-50                    | 4-00 | 4-67 | 5-08 | 6-00 | 7-00 | —    | 6  | 4            | 13-5        | 16-0                  | 18-4 | 20-0 | — |
|              |             | 1                       | 5-83 | 7-00 | 7-33 | 8-00 | —    | —    |    | 4 1/2        | 20-0        | 21-6                  | 22-4 | —    | — |
|              |             | 2                       | 7-00 | 8-00 | 9-33 | —    | —    | —    |    | 5            | 23-4        | 25-4                  | 28-0 | —    | — |
|              |             | 2 1/2                   | 10-5 | —    | —    | —    | —    | —    |    | 6            | 33-0        | —                     | —    | —    | — |
|              |             | —                       | —    | —    | —    | —    | —    | —    |    | —            | —           | —                     | —    | —    | — |

\* Also in 50-foot coils.

† Also in 36-foot coils.

TABLE OF THE WEIGHT OF ROUND COPPER ROD IN LBS. PER LINEAL FOOT.

| Diam. (ins.) | Weight | Diam. (ins.) | Weight | Diam. (ins.) | Weight  | Diam. (ins.) | Weight  | Diam. (ins.) | Weight  |
|--------------|--------|--------------|--------|--------------|---------|--------------|---------|--------------|---------|
| 1/8          | 1-892  | 1/4          | 1-7027 | 1/2          | 4-7298  | 3/4          | 13-6877 | 1            | 29-5594 |
| 5/16         | 2-956  | 3/8          | 1-9982 | 1 1/8        | 5-2140  | 1 1/4        | 15-3251 | 1 1/2        | 31-9722 |
| 3/8          | 4-256  | 1/2          | 2-3176 | 1 1/4        | 5-7228  | 1 1/2        | 17-0750 | 1 3/4        | 34-4813 |
| 7/16         | 5-794  | 5/8          | 2-6605 | 1 3/8        | 6-8109  | 1 1/2        | 18-9161 | 2            | 37-0808 |
| 1/2          | 7-567  | 1            | 3-0270 | 1 1/2        | 7-9931  | 2            | 20-8562 | 2 1/4        | 39-7774 |
| 5/8          | 9-578  | 1 1/8        | 3-4170 | 1 3/4        | 9-2702  | 2 1/4        | 22-8913 | 2 1/2        | 42-5680 |
| 3/4          | 1-1824 | 1 1/4        | 3-8312 | 2            | 10-6420 | 2 3/4        | 25-0188 | 3            | 45-4350 |
| 7/8          | 1-4307 | 1 3/8        | 4-2688 | 2 1/4        | 12-1082 | 3            | 27-2435 | 4            | 48-4330 |

TABLE OF THE WEIGHT OF CAST-IRON BALLS.

| Diam. (ins.) | Wght. (lbs.) | Diam. (ins.) | Wght. (lbs.) | Diam. (ins.) | Weight (lbs.) | Diam. (ins.) | Weight (lbs.) | Diam. (ins.) | Weight (lbs.) |
|--------------|--------------|--------------|--------------|--------------|---------------|--------------|---------------|--------------|---------------|
| —            | —            | —            | —            | 4 1/4        | 12-55         | 6 1/2        | 35-68         | 8 1/4        | 84-57         |
| 1            | 1-14         | 2 1/4        | 2-86         | 4 1/2        | 13-62         | 6 3/4        | 37-81         | 8 1/2        | 92-25         |
| 1 1/4        | 2-20         | 2 1/2        | 3-27         | 4 3/4        | 14-76         | 6 7/8        | 40-04         | 9            | 100-59        |
| 1 1/2        | 2-27         | 3            | 3-72         | 4 7/8        | 15-95         | 6 3/4        | 42-35         | 9 1/4        | 108-99        |
| 1 3/4        | 3-36         | 3 1/2        | 4-20         | 5            | 17-21         | 6 7/8        | 44-75         | 9 1/2        | 118-06        |
| 1 7/8        | 4-47         | 3 3/4        | 4-73         | 5 1/4        | 18-54         | 7            | 47-23         | 9 3/4        | 127-63        |
| 2            | 5-59         | 3 1/2        | 5-29         | 5 1/2        | 19-93         | 7 1/4        | 49-80         | 10           | 137-70        |
| 2 1/4        | 7-74         | 3 3/4        | 5-90         | 5 3/4        | 21-38         | 7 1/2        | 52-47         | 10 1/4       | 148-29        |
| 2 1/2        | 9-91         | 3 3/4        | 6-56         | 5 3/4        | 22-91         | 7 3/4        | 55-23         | 10 1/2       | 159-40        |
| 2 3/4        | 1-10         | 3 3/4        | 7-26         | 5 3/4        | 24-51         | 7 3/4        | 58-09         | 10 3/4       | 171-06        |
| 3            | 1-32         | 3 3/4        | 8-01         | 5 3/4        | 26-18         | 7 3/4        | 60-04         | 11           | 183-28        |
| 3 1/4        | 1-57         | 4            | 8-81         | 5 3/4        | 27-92         | 7 3/4        | 64-09         | 11 1/4       | 196-06        |
| 3 1/2        | 1-84         | 4 1/4        | 9-67         | 6            | 29-74         | 7 3/4        | 67-24         | 11 1/2       | 209-42        |
| 3 3/4        | 2-15         | 4 1/4        | 10-57        | 6 1/4        | 31-64         | 8            | 70-50         | 11 3/4       | 223-58        |
| 4            | 2-49         | 4 1/4        | 11-53        | 6 1/4        | 33-52         | 8 1/4        | 77-32         | 12           | 237-94        |

## SHRINKAGE OF CASTINGS.

The usual allowance for each foot in length is as follows:—

|  |                        |                 |                        |
|--|------------------------|-----------------|------------------------|
| In large cylinders .                     | $= \frac{3}{32}$ inch. | In zinc . . .   | $= \frac{5}{16}$ inch. |
| In small " .                             | $= \frac{1}{16}$ "     | In lead . . .   | $= \frac{5}{16}$ "     |
| In beams and girders                     | $= \frac{1}{16}$ "     | In tin . . .    | $= \frac{1}{4}$ "      |
| In thick brass .                         | $= \frac{3}{32}$ "     | In copper . . . | $= \frac{3}{16}$ "     |
| In thin " .                              | $= \frac{1}{32}$ "     | In bismuth . .  | $= \frac{5}{32}$ "     |
| In cast-iron pipes $= \frac{1}{8}$ inch. |                        |                 |                        |

TABLE OF THE WEIGHT OF COPPER PIPE IN LBS. PER LINEAL FOOT.

| Thick-<br>ness<br>(ins.) | Bore of Pipe in Inches |                |                |                |                |                |                |       | Thick-<br>ness<br>(ins.) |
|--------------------------|------------------------|----------------|----------------|----------------|----------------|----------------|----------------|-------|--------------------------|
|                          | $\frac{1}{4}$          | $\frac{5}{16}$ | $\frac{3}{8}$  | $\frac{1}{2}$  | $\frac{5}{8}$  | $\frac{3}{4}$  | $\frac{7}{8}$  | 1     |                          |
| $\frac{1}{16}$           | .11                    | .13            | .15            | .20            | .25            | .30            | .34            | .39   | $\frac{1}{16}$           |
| $\frac{1}{8}$            | .24                    | .28            | .33            | .43            | .52            | .61            | .71            | .80   | $\frac{1}{8}$            |
| $\frac{3}{16}$           | .39                    | .46            | .53            | .67            | .82            | .96            | 1.10           | 1.24  | $\frac{3}{16}$           |
| $\frac{1}{2}$            | .57                    | .66            | .76            | .95            | 1.14           | 1.32           | 1.51           | 1.70  | $\frac{1}{2}$            |
| $\frac{5}{8}$            | .77                    | .89            | 1.01           | 1.24           | 1.48           | 1.71           | 1.95           | 2.19  | $\frac{5}{8}$            |
| $\frac{3}{4}$            | .99                    | 1.14           | 1.28           | 1.56           | 1.84           | 2.13           | 2.41           | 2.70  | $\frac{3}{4}$            |
| $\frac{7}{8}$            | 1.24                   | 1.41           | 1.57           | 1.90           | 2.23           | 2.57           | 2.90           | 3.23  | $\frac{7}{8}$            |
| 1                        | 1.51                   | 1.70           | 1.89           | 2.27           | 2.65           | 3.03           | 3.41           | 3.78  | 1                        |
| Thick-<br>ness<br>(ins.) | Bore of Pipe in Inches |                |                |                |                |                |                |       | Thick-<br>ness<br>(ins.) |
|                          | $1\frac{1}{8}$         | $1\frac{1}{4}$ | $1\frac{3}{8}$ | $1\frac{1}{2}$ | $1\frac{5}{8}$ | $1\frac{3}{4}$ | $1\frac{7}{8}$ | 2     |                          |
| $\frac{1}{16}$           | .90                    | .99            | 1.09           | 1.18           | 1.28           | 1.37           | 1.47           | 1.56  | $\frac{1}{16}$           |
| $\frac{1}{8}$            | 1.89                   | 2.08           | 2.27           | 2.46           | 2.65           | 2.84           | 3.03           | 3.22  | $\frac{1}{8}$            |
| $\frac{3}{16}$           | 2.98                   | 3.26           | 3.55           | 3.83           | 4.12           | 4.40           | 4.68           | 4.97  | $\frac{3}{16}$           |
| $\frac{1}{2}$            | 4.16                   | 4.54           | 4.91           | 5.30           | 5.67           | 6.05           | 6.43           | 6.81  | $\frac{1}{2}$            |
| Thick-<br>ness<br>(ins.) | Bore of Pipe in Inches |                |                |                |                |                |                |       | Thick-<br>ness<br>(ins.) |
|                          | $2\frac{1}{8}$         | $2\frac{1}{4}$ | $2\frac{3}{8}$ | $2\frac{1}{2}$ | $2\frac{5}{8}$ | $2\frac{3}{4}$ | $2\frac{7}{8}$ | 3     |                          |
| $\frac{1}{16}$           | 1.66                   | 1.75           | 1.84           | 1.94           | 2.04           | 2.13           | 2.22           | 2.32  | $\frac{1}{16}$           |
| $\frac{1}{8}$            | 3.41                   | 3.59           | 3.78           | 3.98           | 4.16           | 4.35           | 4.54           | 4.73  | $\frac{1}{8}$            |
| $\frac{3}{16}$           | 5.25                   | 5.53           | 5.82           | 6.10           | 6.39           | 6.67           | 6.95           | 7.24  | $\frac{3}{16}$           |
| $\frac{1}{2}$            | 7.19                   | 7.57           | 7.94           | 8.33           | 8.70           | 9.08           | 9.46           | 9.84  | $\frac{1}{2}$            |
| Thick-<br>ness<br>(ins.) | Bore of Pipe in Inches |                |                |                |                |                |                |       | Thick-<br>ness<br>(ins.) |
|                          | $3\frac{1}{8}$         | $3\frac{1}{4}$ | $3\frac{3}{8}$ | $3\frac{1}{2}$ | $3\frac{5}{8}$ | $3\frac{3}{4}$ | $3\frac{7}{8}$ | 4     |                          |
| $\frac{1}{16}$           | 2.41                   | 2.51           | 2.60           | 2.70           | 2.79           | 2.89           | 2.98           | 3.08  | $\frac{1}{16}$           |
| $\frac{1}{8}$            | 4.92                   | 5.11           | 5.30           | 5.49           | 5.68           | 5.87           | 6.05           | 6.25  | $\frac{1}{8}$            |
| $\frac{3}{16}$           | 7.52                   | 7.81           | 8.09           | 8.37           | 8.66           | 8.94           | 9.22           | 9.51  | $\frac{3}{16}$           |
| $\frac{1}{2}$            | 10.22                  | 10.60          | 10.97          | 11.35          | 11.73          | 12.11          | 12.49          | 12.87 | $\frac{1}{2}$            |

TABLE OF THE SIZES AND WEIGHT OF SHEET TIN.

| Brand Marks  | Number of Sheets per Box | Size in Ins. |         | Weight per Box |      |      | Brand Marks | Number of Sheets per Box | Size in Ins. |         | Weight per Box |      |      |
|--------------|--------------------------|--------------|---------|----------------|------|------|-------------|--------------------------|--------------|---------|----------------|------|------|
|              |                          | Length       | Breadth | Cwts.          | Qrs. | Lbs. |             |                          | Length       | Breadth | Cwts.          | Qrs. | Lbs. |
| 10, or 1 Com | 225                      | 13           | 10      | 1              | 0    | 0    | DX          | 100                      | 16           | 12      | 1              | 0    | 14   |
| 20           | 225                      | 13           | 9       | 0              | 3    | 21   | DXX         | 100                      | 16           | 12      | 1              | 1    | 7    |
| 30           | 225                      | 12           | 9       | 0              | 3    | 14   | DXXX        | 100                      | 16           | 12      | 1              | 2    | 0    |
| 40           | 225                      | 13           | 10      | 1              | 0    | 7    | DXXXX       | 100                      | 16           | 12      | 1              | 2    | 21   |
| 5X           | 225                      | 13           | 10      | 1              | 1    | 7    | SDC         | 200                      | 15           | 11      | 1              | 2    | 0    |
| 6X           | 225                      | 13           | 10      | 1              | 1    | 0    | SDX         | 200                      | 15           | 11      | 1              | 2    | 21   |
| 7X           | 225                      | 13           | 9       | 1              | 0    | 21   | SDXX        | 200                      | 15           | 11      | 1              | 3    | 14   |
| 8X           | 225                      | 12           | 9       | 1              | 0    | 14   | SDXXX       | 200                      | 15           | 11      | 2              | 0    | 7    |
| 9XX          | 225                      | 13           | 10      | 1              | 1    | 21   | SDXXXX      | 200                      | 15           | 11      | 2              | 1    | 0    |
| 10XXX        | 225                      | 13           | 10      | 1              | 2    | 14   | Wasters     | 225                      | 13           | 10      | 1              | 0    | 14   |
| 11XXXX       | 225                      | 13           | 10      | 1              | 3    | 7    | TF          | 450                      | 13           | 10      | 1              | 0    | 0    |
| DC           | 100                      | 16           | 12      | 0              | 3    | 21   | XTT         | 450                      | 13           | 10      | 1              | 0    | 14   |

TABLE OF THE SIZES AND WEIGHT OF SHEET ZINC.

| Belgian Gauge | Approximate Weight |      |      | Approximate Weight of Sheets |      |      |      |      |      |      |      |      |      |      |      |
|---------------|--------------------|------|------|------------------------------|------|------|------|------|------|------|------|------|------|------|------|
|               | Per Square Foot    |      |      | 7 ft. by 2 ft. 8 in.         |      |      |      |      |      |      |      |      |      |      |      |
|               | Lbs.               | Ozs. | Drs. | Lbs.                         | Ozs. | Drs. | Lbs. | Ozs. | Drs. | Lbs. | Ozs. | Drs. | Lbs. | Ozs. | Drs. |
| 6             | 0                  | 7    | 10   | 8                            | 15   | 2    | 10   | 1    | 0    | 11   | 8    | 0    |      |      |      |
| 7             | 0                  | 8    | 12   | 10                           | 8    | 6    | 11   | 7    | 12   | 13   | 1    | 15   |      |      |      |
| 8             | 0                  | 9    | 13   | 11                           | 7    | 8    | 12   | 14   | 7    | 14   | 11   | 14   |      |      |      |
| 9             | 0                  | 10   | 14   | 12                           | 11   | 10   | 14   | 5    | 2    | 16   | 5    | 13   |      |      |      |
| 10            | 0                  | 13   | 1    | 15                           | 4    | 1    | 17   | 2    | 9    | 19   | 9    | 12   |      |      |      |
| 11            | 0                  | 15   | 4    | 17                           | 12   | 17   | 20   | 0    | 0    | 22   | 13   | 11   |      |      |      |
| 12            | 1                  | 1    | 6    | 20                           | 4    | 13   | 22   | 13   | 15   | 26   | 1    | 9    |      |      |      |
| 13            | 1                  | 3    | 9    | 22                           | 13   | 2    | 25   | 10   | 13   | 29   | 5    | 8    |      |      |      |
| 14            | 1                  | 5    | 12   | 25                           | 5    | 9    | 28   | 8    | 4    | 32   | 9    | 7    |      |      |      |
| 15            | 1                  | 7    | 14   | 27                           | 13   | 15   | 31   | 5    | 10   | 35   | 13   | 6    |      |      |      |
| 16            | 1                  | 10   | 1    | 30                           | 6    | 4    | 34   | 3    | 1    | 39   | 1    | 4    |      |      |      |
| 17            | 1                  | 14   | 6    | 35                           | 7    | 1    | 39   | 13   | 15   | 45   | 9    | 1    |      |      |      |
| 18            | 2                  | 2    | 11   | 40                           | 7    | 13   | 45   | 8    | 12   | 52   | 0    | 14   |      |      |      |

TABLE OF THE SIZES AND WEIGHT OF CORRUGATED IRON SHEETS.

| Thkness.<br>B.W.G. | Size of Sheets | Wght.<br>per<br>Sq. Ft. | Sq.Ft.<br>pr.Tn. | Thkness.<br>B.W.G. | Size of Sheets | Wght.<br>per<br>Sq. Ft. | Sq.Ft.<br>pr.Tn. |
|--------------------|----------------|-------------------------|------------------|--------------------|----------------|-------------------------|------------------|
|                    | Feet.          | Lb. Oz.                 |                  |                    | Feet.          | Lb. Oz.                 |                  |
| 16                 | 6 x 2 to 8 x 3 | 2 1                     | 800              | 21 x 22            | 6 x 2 to 7 x 2 | 1 7                     | 1,600            |
| 17 x 18            | 6 x 2 „ 8 x 3  | 2 4                     | 1,050            | 23 x 24            | 6 x 2 „ 7 x 2  | 1 3                     | 1,900            |
| 19 x 20            | 6 x 2 „ 8 x 3  | 1 12                    | 1,300            | 25 x 26            | 6 x 2 „ 7 x 2  | 1 0                     | 2,250            |

| TABLE OF THE DIMENSIONS AND WEIGHT OF SHIPS' GUNS, SLIDES, AND PIVOT BARS. |                        |                |                  |                 |                             |                    |          |                    |          |                    |
|--|------------------------|----------------|------------------|-----------------|-----------------------------|--------------------|----------|--------------------|----------|--------------------|
| Description of Gun   |                        | Guns           |                  |                 |                             | Slides             |          |                    |          |                    |
|  |                        | Weight         | Length, Nominal. |                 | Length, Muzzle to Trunnions | Greatest Diameter. | Length   | Height, in Front   | Width    |                    |
|  |                        | Tons. Ft. Ins. | Ft. Ins.         | Ins.            | Ins.                        | Ins.               | Ft. Ins. | Ins.               | Ft. Ins. | Ins.               |
| R.M.L.   | 12 $\frac{1}{2}$ -inch | 38-00          | 18               | 9-50            | 149-4                       | 57-50              | —        | —                  | —        | —                  |
|  | 12 "                   | 38-00          | 18               | 9-50            | 149-4                       | 57-50              | —        | —                  | —        | —                  |
|  | 12 "                   | 35-00          | 16               | 11-75           | 122-1                       | 56-00              | —        | —                  | —        | —                  |
|  | 12 "                   | 25-00          | 14               | 3-50            | 110-7                       | 53-50              | 15       | 6 33 $\frac{1}{2}$ | 6        | 2                  |
|  | 11 "                   | 25-00          | 14               | 2               | 111-35                      | 53-00              | 17       | 3                  | —        | —                  |
|  | 10 "                   | 18-00          | 14               | 2               | 108-35                      | 45-00              | 15       | 0 30               | 5        | 0                  |
|  | 9 "                    | 12-00          | 12               | 3               | 90-00                       | 39-00              | 14       | 0 12 $\frac{1}{2}$ | 4        | 3 $\frac{1}{2}$    |
|  | 8 "                    | 9-00           | 11               | 4-50            | 87-00                       | 35-50              | 13       | 0 12 $\frac{1}{2}$ | 4        | 0                  |
|  | 7 "                    | 6-50           | 10               | 6               | 81-25                       | 33-50              | 12       | 0 9 $\frac{3}{4}$  | 3        | 8 $\frac{5}{8}$    |
|  | 7 "                    | 4-50           | 10               | 4-50            | 79-35                       | 26-00              | 11       | 9 16 $\frac{1}{4}$ | 4        | 6                  |
|  | 64-pounder             | 3-20           | 9                | 3-50            | 70-25                       | 22 75              | 12       | 6                  | —        | 3 7                |
|  | 64 "                   | 3-55           | 9                | 0               | 64-34                       | 23-50              | 10       | 6                  | —        | 2 10               |
|  | 40 "                   | 1-70           | 7                | 11              | 62-125                      | 17-75              | —        | —                  | —        | —                  |
|  | 9 "                    | 40             | 5                | 8-50            | 41-25                       | 9-75               | 7        | 6                  | —        | 1 5 $\frac{1}{2}$  |
| R.B.L.   | 9 "                    | 30             | 4                | 10              | 35-00                       | 9-50               | 6        | 10                 | —        | 1 5 $\frac{1}{2}$  |
|  | 7 "                    | Lbs. 200       | 3                | 2-9             | 23-80                       | 6-875              | 5        | 10                 | —        | 1 5                |
|  | 7-inch                 | Tons. 4-10     | 10               | 0               | 74-70                       | 27-70              | —        | —                  | —        | —                  |
|  | 40-pr., screw          | 1-75           | 10               | 1               | 73-875                      | 16-40              | 10       | 6                  | —        | 3 7 $\frac{1}{2}$  |
|  | 40 " wedge             | 1-60           | 8                | 2               | 63-80                       | 19-20              | 10       | 6                  | —        | 3 7 $\frac{1}{2}$  |
|  | 20 " heavy             | 75             | 5                | 6 $\frac{1}{2}$ | 39-50                       | 13-50              | 7        | 6                  | —        | 1 9                |
|  | 20 " light             | 1-65           | 5                | 6 $\frac{1}{2}$ | 40-00                       | 12-50              | 6        | 7 11               | 1        | 9                  |
|  | 12 "                   | 40             | 6                | 0               | 38-75                       | 9-75               | 7        | 6                  | —        | 1 5 $\frac{1}{2}$  |
|  | 9 "                    | 30             | 5                | ■               | 36-50                       | 9-40               | 6        | 10                 | —        | 1 5 $\frac{1}{2}$  |
|  |                        |                |                  | (Extreme)       |                             |                    |          |                    |          |                    |
|  | 100-pr.                | 6-25           | 10               | 10-75           | 75-55                       | 31-50              | 12       | 0                  | —        | 3 11 $\frac{1}{2}$ |
|  | 10-inch                | 4-30           | 10               | 8-72            | 67-20                       | 27-45              | 14       | 0                  | —        | 3 7                |
|  | 8 "                    | 3-25           | 10               | 2-72            | 64-80                       | 23-50              | 12       | 0                  | —        | 3 7 $\frac{1}{2}$  |
|  | 8 "                    | 3-00           | 10               | 86              | 63-60                       | 22-80              | 12       | 0                  | —        | 3 7 $\frac{1}{2}$  |
| S.B.   | 8 "                    | 2-70           | 9                | 2-75            | 57-60                       | 22-75              | 12       | 0                  | —        | 3 7 $\frac{1}{2}$  |
|  | 68-pounder             | 4-75           | 11               | 4-55            | 72-00                       | 22 76              | 14       | 0                  | —        | 3 7                |
|  | 32 "                   | 2-90           | 10               | 7-45            | 68-40                       | 22-60              | 12       | 0                  | —        | 3 7 $\frac{1}{2}$  |
|  | 32 "                   | 2-80           | 10               | 5-14            | 65-10                       | 22 24              | 12       | 0                  | —        | 3 7 $\frac{1}{2}$  |
|  | 32 "                   | 2-50           | 10               | 42              | 66-15                       | 22-46              | 10       | 6                  | —        | 3 7 $\frac{1}{2}$  |
|  | 32 "                   | 2-25           | 9                | 5-96            | 62-47                       | 22-46              | 10       | 6                  | —        | 3 7 $\frac{1}{2}$  |
|  | 32 "                   | 2-10           | 8                | 11-91           | 58-80                       | 21-90              | 12       | 0                  | —        | 3 3                |
|  | 32 "                   | 1-60           | 7                | 5-60            | 44-58                       | 18-60              | 10       | 0                  | —        | 3 3                |
|  | 32 "                   | 1-25           | 6                | 8               | 43-20                       | 17-68              | 10       | 0                  | —        | 3 2                |
|  |                        |                |                  |                 |                             |                    |          |                    |          |                    |
| P.B.   | 24-pr.                 | 65             | 5                | 3-10            | 82-10                       | 12-80              | —        | —                  | —        | —                  |
|  | 12 "                   | 30             | 4                | 1-50            | —                           | 10-20              | —        | —                  | —        | —                  |

TABLE OF THE WEIGHT OF SHIPS' GUNS WITH AMMUNITION AND STORES COMPLETE.

| Description of Gun                    | Gun                      | Carriage | Slide | Powder and Cases |       | Shot and Shell | Stores | Total Weight for one Gun | Shot | Shell |
|---------------------------------------|--------------------------|----------|-------|------------------|-------|----------------|--------|--------------------------|------|-------|
|                                       |                          |          |       |                  |       |                |        |                          |      |       |
| Weight in Tons and Decimals of a Ton. |                          |          |       |                  |       |                |        |                          |      |       |
| No. of Rounds                         |                          |          |       |                  |       |                |        |                          |      |       |
| Revolving Guns                        |                          |          |       |                  |       |                |        |                          |      |       |
| R.M.L.                                | 12-inch, 35 tons, turret | 35.00    | 11.15 | —                | 12.45 | 48.95          | 2.90   | 110.45                   | 66   | 104   |
|                                       | 12 " 25 " "              | 25.00    | 10.80 | —                | 9.45  | 41.50          | 2.45   | 88.70                    | 66   | 104   |
|                                       | 12 " 25 " "              | 25.00    | 5.25  | 8.80             | 9.45  | 41.50          | 3.45   | 93.15                    | 66   | 104   |
|                                       | 10 " 18 " "              | 18.00    | 9.40  | —                | 7.54  | 29.32          | 1.80   | 66.06                    | 66   | 104   |
|                                       | 9 " 12 " "               | 12.00    | 2.34  | 3.61             | 5.34  | 18.15          | 3.40   | 44.84                    | 66   | 104   |
|                                       | 8 " 9 " "                | 9.00     | 2.14  | 3.00             | 4.00  | 13.11          | 3.14   | 34.39                    | 66   | 104   |
|                                       | 7 " 6½ " "               | 6.50     | 1.56  | 2.10             | 3.14  | 8.65           | 2.47   | 24.03                    | 86   | 84    |
|                                       | 7 " 90 cwt.              | 4.50     | 1.20  | 1.65             | 2.25  | 6.25           | 2.30   | 20.15                    | 66   | 104   |
|                                       | 64-pr., 64 " "           | 3.20     | .65   | .95              | 1.25  | 4.50           | 1.25   | 11.80                    | 66   | 104   |
|                                       | R.B.L.                   |          |       |                  |       |                |        |                          |      |       |
| R.B.L.                                | 7-inch " "               | 4.10     | .77   | 1.25             | 1.99  | 6.62           | 2.00   | 16.73                    | 66   | 104   |
|                                       | 40-pr. " "               | 1.75     | .70   | .76              | .91   | 2.81           | 1.41   | 8.44                     | 66   | 104   |
|                                       | 30 " " "                 | .65      | .15   | .17              | .55   | 1.50           | .75    | 3.77                     | 66   | 104   |
| Side Guns                             |                          |          |       |                  |       |                |        |                          |      |       |
| R.M.L.                                | 10-inch, 18 tons         | 18.00    | 4.00  | 6.10             | 3.95  | 14.65          | 4.30   | 51.00                    | 33   | 52    |
|                                       | 9 " 12 " "               | 12.00    | 2.33  | 3.31             | 2.74  | 9.10           | 3.26   | 32.74                    | 33   | 52    |
|                                       | 8 " 9 " "                | 9.00     | 2.10  | 3.00             | 2.10  | 6.50           | 3.04   | 25.74                    | 33   | 52    |
|                                       | 7 " 6½ " "               | 6.50     | 1.55  | 2.10             | 1.63  | 4.30           | 2.73   | 18.81                    | 43   | 52    |
|                                       | 7 " 90 cwt.              | 4.50     | 1.20  | 1.65             | 1.16  | 4.10           | 2.25   | 14.86                    | 33   | 52    |
|                                       | 64-pr., 64 " "           | 3.20     | .41   | —                | .65   | 2.20           | .90    | 7.26                     | 33   | 52    |

\* Not revolving.

| TABLE OF THE WEIGHT OF SHIPS' GUNS WITH AMMUNITION AND STORES COMPLETE (concluded). |                                      |       |          |          |                  |                |                   |                          |                |        |               |
|---|--------------------------------------|-------|----------|----------|------------------|----------------|-------------------|--------------------------|----------------|--------|---------------|
| Description of Gun  |                                      | Gun   | Carriage | Slide    | Powder and Cases | Shot and Shell | Stores            | Total Weight for one Gun | Shot           | Shell  |               |
|   |                                      |       |          |          |                  |                |                   |                          |                |        | No. of Rounds |
| Weight in Tons and Decimals of a Ton  |                                      |       |          |          |                  |                |                   |                          |                |        |               |
| Chase guns  | 10-inch, 18 tons                     | 18.00 | 4.00     | 6.10     | 4.80             | 18.16          | 4.30              | 55.86                    | 43             | 62     |               |
|   | 9 " 12 "                             | 12.00 | 2.31     | 3.90     | 3.40             | 11.20          | 3.30              | 35.51                    | 43             | 62     |               |
|   | 8 " 9 "                              | 9.00  | 2.10     | 3.00     | 2.53             | 8.10           | 3.06              | 27.79                    | 43             | 62     |               |
|   | 7 " 6½ "                             | 6.50  | 1.55     | 2.10     | 1.95             | 5.31           | 2.40              | 19.81                    | 53             | 52     |               |
|   | 7 " 90 cwt.                          | 4.50  | 1.20     | 1.65     | 1.25             | 5.20           | 2.33              | 16.13                    | 48             | 57     |               |
|   | 64-pr., 64 "                         | 3.40  | .41      | —        | .84              | 2.74           | .80               | 8.19                     | 38             | 67     |               |
|   | 7-inch .                             | 4.10  | .74      | 1.25     | 1.26             | 4.07           | 1.60              | 13.02                    | 38             | 67     |               |
|   | 40-pr. .                             | 1.75  | .41      | —        | .60              | 1.80           | .74               | 5.80                     | 38             | 67     |               |
|   | 20 " .                               | .65   | .21      | —        | .35              | .95            | .65               | 2.81                     | 38             | 67     |               |
|   | 7-inch .                             | 4.10  | .74      | 1.25     | 1.00             | 3.31           | 1.60              | 12.00                    | 33             | 52     |               |
|   | 40-pr. .                             | 1.75  | .41      | —        | .44              | 1.46           | .74               | 4.8                      | 33             | 52     |               |
|   | 20 " .                               | .65   | .21      | —        | .26              | .76            | .65               | 2.53                     | 33             | 52     |               |
|   | Boat Guns                            |       | Gun      | Carriage | Slide            | Carriage Top   | Slide with Buffer | Powder and Cases         | Shot and Shell | Stores | Total Weight  |
|   | Weight in Tons and Decimals of a Ton |       |          |          |                  |                |                   |                          |                |        |               |
| Boat guns   | 12-pr.                               | .4000 | .25      | .15      | .11              | .20            | .22               | .80                      | .51            | 2.64   |               |
|   | 9 "                                  | .3000 | .24      | .15      | .11              | .20            | .20               | .61                      | .50            | 2.31   |               |
|   | 9 "                                  | .4000 | .24      | .15      | .14              | .20            | .20               | .70                      | .40            | 2.43   |               |
|   | 9 "                                  | .3000 | .24      | .15      | .14              | .20            | .17               | .70                      | .40            | 2.30   |               |
|   | 7 "                                  | .0875 | —        | —        | .05              | .11            | .06               | .56                      | .20            | .507   |               |



TABLE OF THE WEIGHT OF HOOP IRON IN LBS. PER LINEAL FOOT.

| Breadth (ins.)     | $\frac{3}{4}$  | $\frac{1}{2}$  | $\frac{3}{8}$  | $\frac{1}{4}$  | $\frac{1}{8}$ | 1              | $1\frac{1}{2}$ |
|--------------------|----------------|----------------|----------------|----------------|---------------|----------------|----------------|
| Thickness (B.W.G.) | 23             | 22             | 21             | 20             | 19            | 18             | 17             |
| Weight (lbs.)      | ·0313          | ·0466          | ·0666          | ·0875          | ·1225         | ·1633          | ·2175          |
| Breadth (ins.)     | $1\frac{1}{2}$ | $1\frac{1}{8}$ | $1\frac{1}{4}$ | $1\frac{3}{4}$ | 2             | $2\frac{1}{4}$ | $2\frac{1}{2}$ |
| Thickness (B.W.G.) | 16             | 15             | 15             | 14             | 13            | 12             | 12             |
| Weight (lbs.)      | ·2708          | ·3300          | ·3600          | ·4842          | ·6333         | ·7125          | ·9083          |

TABLE OF THE WEIGHT OF IRON, STEEL, BRASS, AND COPPER WIRE IN LBS. PER LINEAL FOOT.

| B.W.G. | Lbs. per Lineal Foot |       |       |        | B.W.G. | Lbs. per Lineal Foot |       |       |        |
|--------|----------------------|-------|-------|--------|--------|----------------------|-------|-------|--------|
|        | Iron                 | Steel | Brass | Copper |        | Iron                 | Steel | Brass | Copper |
| 0      | ·9058                | ·3092 | ·3843 | ·3517  | 11     | ·0413                | ·0418 | ·0452 | ·0475  |
| 1      | ·2575                | ·2604 | ·2815 | ·2962  | 12     | ·0314                | ·0318 | ·0343 | ·0361  |
| 2      | ·2134                | ·2157 | ·2332 | ·2454  | 13     | ·0234                | ·0236 | ·0255 | ·0269  |
| 3      | ·1802                | ·1822 | ·1970 | ·2072  | 14     | ·0169                | ·0171 | ·0185 | ·0195  |
| 4      | ·1511                | ·1528 | ·1652 | ·1738  | 15     | ·0137                | ·0139 | ·0150 | ·0158  |
| 5      | ·1246                | ·1259 | ·1362 | ·1433  | 16     | ·0105                | ·0106 | ·0115 | ·0121  |
| 6      | ·1145                | ·1157 | ·1251 | ·1316  | 17     | ·0080                | ·0081 | ·0087 | ·0092  |
| 7      | ·0925                | ·0935 | ·1011 | ·1064  | 18     | ·0061                | ·0062 | ·0067 | ·0070  |
| 8      | ·0729                | ·0737 | ·0797 | ·0838  | 19     | ·0047                | ·0047 | ·0051 | ·0054  |
| 9      | ·0660                | ·0668 | ·0722 | ·0759  | 20     | ·0032                | ·0033 | ·0034 | ·0037  |
| 10     | ·0496                | ·0502 | ·0543 | ·0571  | 21     | ·0017                | ·0018 | ·0019 | ·0022  |

TABLE OF THE WEIGHT OF NUTS AND BOLT-HEADS IN LBS. PER PAIR.

| Diameter of bolt (ins.) | $\frac{1}{4}$  | $\frac{3}{8}$  | $\frac{1}{2}$  | $\frac{3}{4}$  | $\frac{1}{2}$  | 1    | 1              |
|-------------------------|----------------|----------------|----------------|----------------|----------------|------|----------------|
| Hexagon head and nut    | ·050           | ·100           | ·200           | ·365           | ·500           | ·770 | 1·25           |
| Square head and nut     | ·062           | ·121           | ·240           | ·400           | ·560           | ·880 | 1·31           |
| Diameter of bolt (ins.) | $1\frac{1}{8}$ | $1\frac{1}{4}$ | $1\frac{3}{8}$ | $1\frac{1}{2}$ | $1\frac{3}{4}$ | 2    | $2\frac{1}{4}$ |
| Hexagon head and nut    | 1·75           | 2·13           | 3·00           | 3·75           | 5·75           | 8·75 | 17·00          |
| Square head and nut     | 2·10           | 2·56           | 3·60           | 4·42           | 7·00           | 10·5 | 21·00          |

TABLE OF THE SIZES AND WEIGHT OF LENOX'S PATENT  
MALLEABLE CAST-IRON DEAD-EYES.

| Pattern Number             | Description | Shrouds         |                      | Lanyards        |                  | Test Load       | Lower Dead-eyes  |                    | Average Weight |
|----------------------------|-------------|-----------------|----------------------|-----------------|------------------|-----------------|------------------|--------------------|----------------|
|                            |             | Size            | Diameter when served | Size            | Diameter         |                 | Diameter of Bolt | Width between Jaws |                |
|                            | For         | Inch.           | Inch.                | Inch.           | Inch.            | Tons            | Inch.            | Inch.              | Lbs.           |
| 1 upper<br>1A lower        | Wire        | 7               | 2 $\frac{1}{2}$      | 7               | 2 $\frac{3}{8}$  | 25              | 2 $\frac{3}{8}$  | 2 $\frac{1}{4}$    | { 70<br>60     |
| 2 upper<br>2A lower        |             | 6               | 2 $\frac{1}{2}$      | 6               | 2 $\frac{1}{8}$  | 20              | 2 $\frac{1}{8}$  | 2 $\frac{1}{2}$    | { 54<br>43     |
| 3 upper<br>3A lower        | "           | 5               | 2 $\frac{1}{8}$      | 5               | 1 $\frac{3}{4}$  | 15              | 1 $\frac{3}{4}$  | 2 $\frac{1}{4}$    | { 30<br>25     |
| 4 upper<br>4A lower        | "           | 4               | 1 $\frac{5}{8}$      | 4               | 1 $\frac{1}{2}$  | 10              | 1 $\frac{1}{2}$  | 1 $\frac{5}{8}$    | { 18<br>16     |
| 5 upper<br>5A lower        | "           | 3               | 1 $\frac{1}{2}$      | 3               | 1 $\frac{1}{8}$  | 5               | 1 $\frac{1}{8}$  | 1 $\frac{3}{8}$    | { 14<br>10     |
| 6 upper<br>6A lower        | "           | 2 $\frac{1}{2}$ | 1 $\frac{5}{8}$      | 2 $\frac{1}{2}$ | 1 $\frac{1}{16}$ | 4 $\frac{1}{2}$ | 1                | 1 $\frac{1}{4}$    | { 11<br>8      |
| 7 upper<br>7A lower        | "           | 2               | $\frac{7}{8}$        | 2               | $\frac{3}{4}$    | 3               | $\frac{3}{4}$    | $\frac{7}{8}$      | { 7<br>5       |
| <i>For Top Back-stays.</i> |             |                 |                      |                 |                  |                 |                  |                    |                |
| 11 upper<br>11A lower      | Rope        | 8 $\frac{1}{2}$ | 3                    | 4               | 1 $\frac{1}{2}$  | 15              | 1 $\frac{1}{2}$  | 1 $\frac{3}{4}$    | { 38<br>16     |
| 12 upper<br>12A lower      |             | 7               | 2 $\frac{1}{2}$      | 3 $\frac{1}{4}$ | 1 $\frac{1}{4}$  | 10              | 1 $\frac{1}{4}$  | 1 $\frac{1}{4}$    | { 21<br>13     |
| 13 upper<br>13A lower      | "           | 5 $\frac{1}{2}$ | 2                    | 3               | 1 $\frac{1}{8}$  | 5               | 1 $\frac{1}{8}$  | 1 $\frac{1}{8}$    | { 15<br>10     |
| 14 upper<br>14A lower      | "           | 4               | 1 $\frac{5}{8}$      | 2               | $\frac{5}{4}$    | 3               | $\frac{3}{4}$    | $\frac{7}{8}$      | { 7<br>5       |
| 15 upper<br>15A lower      | "           | 2 $\frac{1}{2}$ | 1                    | 1 $\frac{1}{2}$ | $\frac{5}{8}$    | 2               | $\frac{3}{8}$    | $\frac{3}{4}$      | { 3.5<br>2.5   |

TABLE OF THE SIZES OF LENOX'S PATENT MALLEABLE CAST-IRON BLOCKS AS USED IN H.R. MAJESTY'S DOCKYARDS.

| Nos. | Size of Block | Rope     |           |                  | Sheaves  |           |                 | Description of Blocks | Proof Strain | Dimensions of Shackles |              |            |                  |
|------|---------------|----------|-----------|------------------|----------|-----------|-----------------|-----------------------|--------------|------------------------|--------------|------------|------------------|
|      |               | To Reeve | Test Load | Diameter of Rope | Diameter | Thickness | Diameter of Pin |                       |              | Diameter of Iron       | In the Clear |            | Diameter of Bolt |
|      |               |          |           |                  |          |           |                 |                       |              |                        | Lgth.        | Bolt Width |                  |
|      | L.            | Ins.     | T.        | Ins.             | I.       | L.        | I.              |                       | T.           | Ins.                   | Lgth.        | Bolt Width | Ins.             |
| 1    | 4             | 1½       | ¾         | ½                | 3        | ¾         | ¾               | { Single              | 1            | 1                      | 1            | 1          | 1                |
|      |               |          |           |                  |          |           |                 | { Double              | 1            | 1                      | 1            | 1          | 1                |
| 1½   | 5             | 2        | 1         | ¾                | 4        | ¾         | ¾               | { Treble              | 1            | 1                      | 1            | 1          | 1                |
|      |               |          |           |                  |          |           |                 | { Single              | 1            | 1                      | 1            | 1          | 1                |
| 2    | 6             | 2½       | 1½        | 1                | 5        | 1         | ¾               | { Single              | 2            | 2                      | 2            | 2          | 2                |
|      |               |          |           |                  |          |           |                 | { Double              | 2            | 2                      | 2            | 2          | 2                |
|      |               |          |           |                  |          |           |                 | { Treble              | 3            | 3                      | 3            | 3          | 3                |
| 3    | 8             | 3        | 1½        | 1                | 6        | 1½        | ¾               | { Single              | 2½           | 2½                     | 2½           | 2½         | 2½               |
|      |               |          |           |                  |          |           |                 | { Double              | 3            | 3                      | 3            | 3          | 3                |
|      |               |          |           |                  |          |           |                 | { Treble              | 4½           | 4½                     | 4½           | 4½         | 4½               |
| 4    | 10            | 3½       | 2         | 1½               | 7½       | 1½        | 1               | { Single              | 3            | 3                      | 3            | 3          | 3                |
|      |               |          |           |                  |          |           |                 | { Double              | 4            | 4                      | 4            | 4          | 4                |
|      |               |          |           |                  |          |           |                 | { Treble              | 6            | 6                      | 6            | 6          | 6                |
| 5    | 12            | 4 & 4½   | 3         | 1½ & 1¾          | 9        | 1½        | 1½              | { Single              | 4½           | 1                      | 3            | 1          | 1                |
|      |               |          |           |                  |          |           |                 | { Double              | 6            | 1½                     | 3½           | 1          | 1                |
|      |               |          |           |                  |          |           |                 | { Treble              | 9            | 1½                     | 3½           | 1          | 1                |
| 6    | 14            | 5        | 3½        | 1¾               | 10       | 2         | 1½              | { Single              | 5½           | 1½                     | 3½           | 1          | 1                |
|      |               |          |           |                  |          |           |                 | { Double              | 7            | 1½                     | 3½           | 1          | 1                |
|      |               |          |           |                  |          |           |                 | { Treble              | 10½          | 1½                     | 3½           | 1          | 1                |
| 7    | 16            | 6 & 7    | 5½        | 1½ & 2           | 12       | 2½        | 1½              | { Single              | 8            | 1½                     | 3½           | 2          | 1                |
|      |               |          |           |                  |          |           |                 | { Double              | 11           | 1½                     | 3½           | 2          | 1                |
|      |               |          |           |                  |          |           |                 | { Treble              | 16           | 1½                     | 4            | 2          | 1                |
| 8    | 18            | 7½       | 9         | 2½               | 13½      | 2½        | 1½              | { Single              | 13           | 1½                     | 4½           | 2½         | 1                |
|      |               |          |           |                  |          |           |                 | { Double              | 18           | 1½                     | 4½           | 2½         | 1                |
|      |               |          |           |                  |          |           |                 | { Treble              | 27           | 1½                     | 4½           | 2½         | 1                |
| 9    | 20            | 8½ & 9   | 10½       | 2½ & 2¾          | 15       | 3½        | 2               | { Single              | 16½          | 1½                     | 4½           | 2½         | 1                |
|      |               |          |           |                  |          |           |                 | { Double              | 21           | 1½                     | 4½           | 2½         | 1                |
|      |               |          |           |                  |          |           |                 | { Treble              | 31½          | 1½                     | 4½           | 2½         | 2                |

## TO FIND THE APPROXIMATE WEIGHT OF CASTINGS OR FORGINGS FROM THEIR WOODEN PATTERNS.

| Description of Pattern.                             |      |   | Weight in |                 |
|---|------|---|-----------|-----------------|
| Weight of pattern in dry plane-tree, multiplied by  | 17.0 | Weight of pattern in dry deal, multiplied by        | 24.0      | cast lead.      |
|   | 15.3 |   | 19.3      | " copper.       |
|   | 18.3 |   | 19.3      | " gun-metal.    |
|   | 17.8 |   | 18.8      | " brass.        |
|   | 12.0 |   | 17.4      | Bessemer steel. |
|   | 11.8 |   | 17.8      | cast "          |
| Weight of pattern in dry yellow pine, multiplied by | 11.8 | Weight of pattern in dry yellow pine, multiplied by | 17.1      | wrought iron.   |
|   | 11.8 |   | 16.0      | cast "          |
|   | 11.8 |   |           |                 |
|   | 11.8 |   |           |                 |

TABLE OF THE WEIGHT AND STRENGTH OF SAIL CANVAS  
IN LBS. PER BOLT OF 24 INS. WIDE.

| No. of canvases         | 0  | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   |
|-------------------------|----|-----|-----|-----|-----|-----|-----|-----|-----|
| Length of bolt (feet)   | 39 | 39  | 39  | 39  | 39  | 39  | 39  | 40  | 40  |
| Weight of bolt (lbs.)   | 48 | 46  | 43  | 40  | 36  | 33  | 30  | 27  | 25  |
| Tenacity in lbs. (weft) | —  | 480 | 460 | 440 | 400 | 370 | 350 | 330 | 380 |
| Tenacity in lbs. (warp) | —  | 340 | 320 | 300 | 280 | 260 | 250 | 330 | 310 |

TABLE OF THE NUMBER OF CUBIC FEET REQUIRED TO STOW  
100 FATHOMS OF CHAIN CABLE.

|                       |                |                |                |                 |                |                 |                |                |                |
|-----------------------|----------------|----------------|----------------|-----------------|----------------|-----------------|----------------|----------------|----------------|
| Diam. of chain (ins.) | $\frac{1}{2}$  | $\frac{3}{4}$  | $\frac{1}{2}$  | $\frac{13}{16}$ | $\frac{7}{8}$  | $\frac{15}{16}$ | 1              | $1\frac{1}{8}$ | $1\frac{1}{4}$ |
| No. of cubic feet     | 14             | 17             | 20             | 23              | 27             | 31              | 35             | 44             | 55             |
| Diam. of chain (ins.) | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$ | $1\frac{1}{2}$  | $1\frac{1}{2}$ | 2               | $2\frac{1}{8}$ | $2\frac{1}{4}$ | $2\frac{1}{2}$ |
| No. of cubic feet     | 66             | 79             | 92             | 107             | 123            | 140             | 158            | 177            | 218            |

## STOWAGE OF CHAIN CABLE.

D = diam. of chain in ins.; S = No. of cub. ft. to stow 100 fathoms.  
 $S = D^2 \times 35.$

TABLE OF THE WEIGHT AND STRENGTH OF FLAT HEMP  
AND WIRE ROPE.

| Hemp                              |                          | Iron                            |                          | Steel                           |                          | Equivalent Strength  |                       |
|-----------------------------------|--------------------------|---------------------------------|--------------------------|---------------------------------|--------------------------|----------------------|-----------------------|
| Size in Inches                    | Weight per Fathom (lbs.) | Size in Inches                  | Weight per Fathom (lbs.) | Size in Inches                  | Weight per Fathom (lbs.) | Working Load in Tons | Breaking Load in Tons |
| 4 × 1 $\frac{1}{2}$               | 20                       | 2 $\frac{1}{2}$ × $\frac{1}{2}$ | 11                       | —                               | —                        | 2.20                 | 20                    |
| 5 × 1 $\frac{1}{2}$               | 24                       | 2 $\frac{1}{2}$ × $\frac{3}{4}$ | 13                       | —                               | —                        | 2.60                 | 23                    |
| 5 $\frac{1}{2}$ × 1 $\frac{1}{2}$ | 26                       | 2 $\frac{1}{2}$ × $\frac{7}{8}$ | 15                       | —                               | —                        | 3.00                 | 27                    |
| 5 $\frac{1}{2}$ × 1 $\frac{3}{4}$ | 28                       | 3 × $\frac{1}{2}$               | 16                       | 2 × $\frac{1}{2}$               | 10                       | 3.20                 | 28                    |
| 6 × 1 $\frac{3}{4}$               | 30                       | 3 $\frac{1}{2}$ × $\frac{1}{2}$ | 18                       | 2 $\frac{1}{2}$ × $\frac{1}{2}$ | 11                       | 3.60                 | 32                    |
| 7 × 1 $\frac{3}{4}$               | 36                       | 3 $\frac{1}{2}$ × $\frac{3}{4}$ | 20                       | 2 $\frac{1}{2}$ × $\frac{3}{4}$ | 12                       | 4.00                 | 36                    |
| 8 $\frac{1}{2}$ × 2 $\frac{1}{2}$ | 40                       | 3 $\frac{1}{2}$ × $\frac{7}{8}$ | 22                       | 2 $\frac{1}{2}$ × $\frac{7}{8}$ | 13                       | 4.40                 | 40                    |
| 8 $\frac{1}{2}$ × 2 $\frac{3}{4}$ | 45                       | 4 × $\frac{1}{2}$               | 25                       | 2 $\frac{3}{4}$ × $\frac{1}{2}$ | 15                       | 5.00                 | 45                    |
| 9 × 2 $\frac{3}{4}$               | 50                       | 4 $\frac{1}{2}$ × $\frac{1}{2}$ | 28                       | 3 × $\frac{1}{2}$               | 16                       | 5.60                 | 50                    |
| 9 $\frac{1}{2}$ × 2 $\frac{3}{4}$ | 55                       | 4 $\frac{1}{2}$ × $\frac{3}{4}$ | 32                       | 3 $\frac{1}{2}$ × $\frac{1}{2}$ | 18                       | 6.40                 | 56                    |
| 10 × 2                            | 60                       | 4 $\frac{1}{2}$ × $\frac{7}{8}$ | 34                       | 3 $\frac{1}{2}$ × $\frac{3}{4}$ | 20                       | 6.80                 | 60                    |

TABLE OF THE LOGARITHMIC SINES, TANGENTS, AND SECANTS TO EVERY POINT AND QUARTER-POINT OF THE COMPASS.

| Points | Sine     | Cosine    | Tangent   | Cotangent | Secant    | Cosecant  | Points |
|--------|----------|-----------|-----------|-----------|-----------|-----------|--------|
| 0      | 0·000000 | 10·000000 | 0·000000  | Infinite  | 10·000000 | Infinite  | 8      |
| 0¼     | 8·690796 | 9·999477  | 8·691319  | 11·308681 | 10·000523 | 11·309204 | 7¾     |
| 0½     | 8·991302 | 9·997904  | 8·993898  | 11·006602 | 10·002096 | 11·008698 | 7½     |
| 0¾     | 9·166520 | 9·995274  | 9·171247  | 10·828758 | 10·004726 | 10·833480 | 7¼     |
| 1      | 9·290286 | 9·991574  | 9·298662  | 10·701338 | 10·008426 | 10·709764 | 7      |
| 1¼     | 9·385571 | 9·986786  | 9·398785  | 10·601215 | 10·013214 | 10·614429 | 6¾     |
| 1½     | 9·462824 | 9·980885  | 9·481939  | 10·518061 | 10·019115 | 10·537176 | 6½     |
| 1¾     | 9·527488 | 9·973841  | 9·553647  | 10·446358 | 10·026159 | 10·472512 | 6¼     |
| 2      | 9·582840 | 9·965615  | 9·617224  | 10·382776 | 10·034385 | 10·417160 | 6      |
| 2¼     | 9·630992 | 9·956163  | 9·674829  | 10·325171 | 10·043837 | 10·369008 | 5¾     |
| 2½     | 9·673387 | 9·945430  | 9·727957  | 10·272043 | 10·054570 | 10·326613 | 5½     |
| 2¾     | 9·711050 | 9·933350  | 9·777700  | 10·222300 | 10·066650 | 10·288950 | 5¼     |
| 3      | 9·744739 | 9·919846  | 9·824893  | 10·175107 | 10·080154 | 10·255261 | 5      |
| 3¼     | 9·775027 | 9·904828  | 9·870199  | 10·129801 | 10·095172 | 10·224973 | 4¾     |
| 3½     | 9·802359 | 9·888185  | 9·914173  | 10·085827 | 10·111815 | 10·197641 | 4½     |
| 3¾     | 9·827084 | 9·869790  | 9·957295  | 10·042705 | 10·130210 | 10·172916 | 4¼     |
| 4      | 9·849485 | 9·849485  | 10·000000 | 10·000000 | 10·150515 | 10·150515 | 4      |
| Points | Cosine   | Sine      | Cotangent | Tangent   | Cosecant  | Secant    | Points |

TABLE OF DISTANCES OF THE VISIBLE HORIZON IN NAUTICAL MILES, THE HEIGHT OF THE EYE BEING IN FEET.

| Height | Distance | Height | Distance | Height | Distance | Height | Distance | Height | Distance | Height | Distance |
|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|--------|----------|
| 1      | 1·06     | 21     | 4·87     | 41     | 6·81     | 61     | 8·31     | 81     | 9·57     | 101    | 10·69    |
| 2      | 1·50     | 22     | 4·99     | 42     | 6·89     | 62     | 8·37     | 82     | 9·63     | 102    | 10·74    |
| 3      | 1·84     | 23     | 5·10     | 43     | 6·97     | 63     | 8·44     | 83     | 9·69     | 103    | 10·79    |
| 4      | 2·13     | 24     | 5·21     | 44     | 7·05     | 64     | 8·51     | 84     | 9·75     | 104    | 10·84    |
| 5      | 2·38     | 25     | 5·32     | 45     | 7·13     | 65     | 8·58     | 85     | 9·80     | 105    | 10·89    |
| 6      | 2·60     | 26     | 5·42     | 46     | 7·21     | 66     | 8·64     | 86     | 9·86     | 106    | 10·95    |
| 7      | 2·81     | 27     | 5·52     | 47     | 7·29     | 67     | 8·70     | 87     | 9·92     | 107    | 11·00    |
| 8      | 3·01     | 28     | 5·62     | 48     | 7·37     | 68     | 8·77     | 88     | 9·98     | 108    | 11·05    |
| 9      | 3·19     | 29     | 5·72     | 49     | 7·44     | 69     | 8·83     | 89     | 10·03    | 109    | 11·10    |
| 10     | 3·36     | 30     | 5·82     | 50     | 7·52     | 70     | 8·89     | 90     | 10·09    | 110    | 11·15    |
| 11     | 3·53     | 31     | 5·92     | 51     | 7·59     | 71     | 8·96     | 91     | 10·14    | 111    | 11·20    |
| 12     | 3·68     | 32     | 6·01     | 52     | 7·67     | 72     | 9·02     | 92     | 10·20    | 112    | 11·25    |
| 13     | 3·83     | 33     | 6·11     | 53     | 7·74     | 73     | 9·09     | 93     | 10·25    | 113    | 11·30    |
| 14     | 3·98     | 34     | 6·20     | 54     | 7·81     | 74     | 9·15     | 94     | 10·31    | 114    | 11·35    |
| 15     | 4·12     | 35     | 6·29     | 55     | 7·89     | 75     | 9·21     | 95     | 10·36    | 115    | 11·40    |
| 16     | 4·25     | 36     | 6·38     | 56     | 7·96     | 76     | 9·27     | 96     | 10·42    | 116    | 11·45    |
| 17     | 4·38     | 37     | 6·47     | 57     | 8·03     | 77     | 9·33     | 97     | 10·47    | 117    | 11·50    |
| 18     | 4·51     | 38     | 6·56     | 58     | 8·10     | 78     | 9·39     | 98     | 10·53    | 118    | 11·55    |
| 19     | 4·53     | 39     | 6·64     | 59     | 8·17     | 79     | 9·45     | 99     | 10·58    | 119    | 11·60    |
| 20     | 4·76     | 40     | 6·73     | 60     | 8·24     | 80     | 9·51     | 100    | 10·63    | 120    | 11·65    |

TABLE OF THE VALUES OF THE GAUGES IN DECIMALS OF THE INCH.

*Birmingham Gauge for Iron Wire, and Sheet Iron, and Steel.*

| Mark | Size | Mark | Size | Mark | Size | Mark | Size | Mark | Size |
|------|------|------|------|------|------|------|------|------|------|
| 0000 | ·454 | 5    | ·220 | 18   | ·095 | 21   | ·082 | 29   | ·013 |
| 000  | ·425 | 6    | ·208 | 14   | ·088 | 22   | ·028 | 30   | ·012 |
| 00   | ·380 | 7    | ·180 | 15   | ·072 | 23   | ·025 | 31   | ·010 |
| 0    | ·340 | 8    | ·135 | 16   | ·065 | 24   | ·022 | 32   | ·009 |
| 1    | 300  | 9    | ·148 | 17   | ·058 | 25   | ·020 | 33   | ·008 |
| 2    | ·284 | 10   | ·134 | 18   | ·049 | 26   | ·018 | 34   | ·007 |
| 3    | ·259 | 11   | ·120 | 19   | ·042 | 27   | ·016 | 35   | ·005 |
| 4    | ·238 | 12   | ·109 | 20   | ·035 | 28   | ·014 | 36   | ·004 |

*Birmingham Gauge for Sheet Metals, Brass, Gold, Silver, &c.*

| Mark | Size | Mark | Size | Mark | Size | Mark | Size | Mark | Size |
|------|------|------|------|------|------|------|------|------|------|
| —    | —    | —    | —    | —    | —    | —    | —    | 29   | ·124 |
| 1    | ·004 | 8    | ·016 | 15   | ·047 | 22   | ·074 | 30   | ·126 |
| 2    | ·005 | 9    | ·019 | 16   | ·051 | 23   | ·077 | 31   | ·133 |
| 3    | ·008 | 10   | ·024 | 17   | ·057 | 24   | ·082 | 32   | ·143 |
| 4    | ·010 | 11   | ·029 | 18   | ·061 | 25   | ·095 | 33   | ·145 |
| 5    | ·012 | 12   | ·034 | 19   | ·064 | 26   | ·103 | 34   | ·148 |
| 6    | ·013 | 13   | ·036 | 20   | ·067 | 27   | ·113 | 35   | ·158 |
| 7    | ·015 | 14   | ·041 | 21   | ·072 | 28   | ·120 | 36   | ·167 |

*Lancashire Gauge for Round Steel Wire, and also for Pinion Wire.*

| Mark | Size | Mark | Size | Mark | Size | Mark | Size | Mark | Size |
|------|------|------|------|------|------|------|------|------|------|
| —    | —    | 58   | ·041 | 35   | ·107 | 12   | ·185 | L    | ·290 |
| 80   | ·013 | 57   | ·042 | 34   | ·109 | 11   | ·189 | M    | ·295 |
| 79   | ·014 | 56   | ·044 | 33   | ·111 | 10   | ·190 | N    | ·302 |
| 78   | ·015 | 55   | ·050 | 32   | ·115 | 9    | ·191 | O    | ·316 |
| 77   | ·016 | 54   | ·055 | 31   | ·118 | 8    | ·192 | P    | ·323 |
| 76   | ·018 | 53   | ·058 | 30   | ·125 | 7    | ·195 | Q    | ·332 |
| 75   | ·019 | 52   | ·060 | 29   | ·134 | 6    | ·198 | R    | ·339 |
| 74   | ·022 | 51   | ·064 | 28   | ·138 | 5    | ·201 | S    | ·348 |
| 73   | ·023 | 50   | ·067 | 27   | ·141 | 4    | ·204 | T    | ·358 |
| 72   | ·024 | 49   | ·070 | 26   | ·148 | 3    | ·209 | U    | ·368 |
| 71   | ·026 | 48   | ·073 | 25   | ·146 | 2    | ·219 | V    | ·377 |
| 70   | ·027 | 47   | ·076 | 24   | ·148 | 1    | ·227 | W    | ·386 |
| 69   | ·029 | 46   | ·078 | 23   | ·150 | A    | ·234 | X    | ·397 |
| 68   | ·030 | 45   | ·080 | 22   | ·152 | B    | ·238 | Y    | ·404 |
| 67   | ·031 | 44   | ·084 | 21   | ·157 | C    | ·242 | Z    | ·413 |
| 66   | ·032 | 43   | ·086 | 20   | ·160 | D    | ·246 | A1   | ·420 |
| 65   | ·033 | 42   | ·091 | 19   | ·164 | E    | ·250 | B1   | ·431 |
| 64   | ·034 | 41   | ·095 | 18   | ·167 | F    | ·257 | C1   | ·443 |
| 63   | ·035 | 40   | ·096 | 17   | ·169 | G    | ·261 | D1   | ·452 |
| 62   | ·036 | 39   | ·098 | 16   | ·174 | H    | ·266 | E1   | ·462 |
| 61   | ·038 | 38   | ·100 | 15   | ·175 | I    | ·272 | F1   | ·475 |
| 60   | ·039 | 37   | ·102 | 14   | ·177 | J    | ·277 | G1   | ·484 |
| 59   | ·040 | 36   | ·105 | 13   | ·180 | K    | ·281 | H1   | ·494 |

TABLE OF THE VALUES OF WHITWORTH'S WIRE GAUGE  
IN DECIMALS OF AN INCH.

| Wire | Size | Mark | Size | Mark | Size | Mark | Size | Mark | Size |
|------|------|------|------|------|------|------|------|------|------|
| 1    | .001 | 14   | .014 | 34   | .034 | 90   | .090 | 280  | .280 |
| 2    | .002 | 15   | .015 | 36   | .036 | 95   | .095 | 300  | .300 |
| 3    | .003 | 16   | .016 | 38   | .038 | 100  | .100 | 325  | .325 |
| 4    | .004 | 17   | .017 | 40   | .040 | 110  | .110 | 350  | .350 |
| 5    | .005 | 18   | .018 | 45   | .045 | 120  | .120 | 375  | .375 |
| 6    | .006 | 19   | .019 | 50   | .050 | 135  | .135 | 400  | .400 |
| 7    | .007 | 20   | .020 | 55   | .055 | 150  | .150 | 425  | .425 |
| 8    | .008 | 22   | .022 | 60   | .060 | 165  | .165 | 450  | .450 |
| 9    | .009 | 24   | .024 | 65   | .065 | 180  | .180 | 475  | .475 |
| 10   | .010 | 26   | .026 | 70   | .070 | 200  | .200 | 500  | .500 |
| 11   | .011 | 28   | .028 | 75   | .075 | 220  | .220 | —    | —    |
| 12   | .012 | 30   | .030 | 80   | .080 | 240  | .240 | —    | —    |
| 13   | .013 | 32   | .032 | 85   | .085 | 260  | .260 | —    | —    |

TABLE OF THE WEIGHT OF 100 PAN-HEADED RIVETS  
IN LBS.

| Diam.<br>(Inch.) | Length under Head in Inches |               |                |                |                |                |                |                |                |                | Diam.<br>(Inch.) |
|------------------|-----------------------------|---------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------|
|                  | $\frac{1}{4}$               | $\frac{3}{8}$ | $\frac{1}{2}$  | $\frac{3}{4}$  | 1              | $1\frac{1}{8}$ | $1\frac{1}{4}$ | $1\frac{3}{8}$ | $1\frac{1}{2}$ | $1\frac{3}{4}$ |                  |
| $\frac{1}{8}$    | 1.25                        | 1.44          | 1.62           | 1.81           | 1.99           | 2.20           | 2.35           | 2.54           | 2.72           | 2.90           | $\frac{1}{8}$    |
| $\frac{3}{16}$   | 3.46                        | 3.86          | 4.27           | 4.69           | 5.09           | 5.50           | 5.91           | 6.43           | 6.94           | 7.25           | $\frac{3}{16}$   |
| $\frac{1}{4}$    | 7.27                        | 8.00          | 8.73           | 9.45           | 10.18          | 10.50          | 11.65          | 12.89          | 13.12          | 13.86          | $\frac{1}{4}$    |
| $\frac{5}{16}$   | 13.00                       | 14.24         | 15.37          | 16.51          | 17.65          | 18.80          | 19.93          | 21.10          | 22.30          | 23.35          | $\frac{5}{16}$   |
| $\frac{3}{8}$    | 20.75                       | 22.95         | 24.35          | 26.15          | 27.22          | 29.87          | 31.70          | 32.70          | 34.40          | 36.34          | $\frac{3}{8}$    |
| $\frac{7}{16}$   | 32.23                       | 34.46         | 36.69          | 38.91          | 41.15          | 43.40          | 45.64          | 47.89          | 50.12          | 52.35          | $\frac{7}{16}$   |
| $\frac{1}{2}$    | 46.54                       | 49.44         | 52.35          | 55.26          | 58.17          | 61.10          | 64.00          | 66.93          | 69.81          | 72.72          | $\frac{1}{2}$    |
| Diam.<br>(Inch.) | Length under Head in Inches |               |                |                |                |                |                |                |                |                | Diam.<br>(Inch.) |
|                  | $1\frac{1}{4}$              | 2             | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{3}{4}$ | 3              | $3\frac{1}{4}$ | $3\frac{1}{2}$ | $3\frac{3}{4}$ | 4              |                  |
| $\frac{5}{8}$    | 3.08                        | 3.43          | 3.80           | 4.16           | 4.53           | 4.90           | 5.26           | 5.63           | 5.99           | 6.35           | $\frac{5}{8}$    |
| $\frac{3}{4}$    | 7.55                        | 8.37          | 9.19           | 10.01          | 10.84          | 11.68          | 12.49          | 13.32          | 14.14          | 14.96          | $\frac{3}{4}$    |
| $\frac{7}{8}$    | 14.59                       | 15.10         | 17.50          | 18.96          | 20.41          | 21.86          | 23.32          | 24.79          | 26.24          | 27.71          | $\frac{7}{8}$    |
| $\frac{15}{16}$  | 24.48                       | 26.75         | 29.11          | 31.47          | 33.83          | 35.84          | 38.11          | 40.39          | 42.66          | 44.94          | $\frac{15}{16}$  |
| 1                | 37.67                       | 40.95         | 44.23          | 47.50          | 51.10          | 54.06          | 57.34          | 60.61          | 63.90          | 67.17          | 1                |
| $1\frac{1}{8}$   | 54.59                       | 59.05         | 64.51          | 67.97          | 72.44          | 76.89          | 81.35          | 85.81          | 90.26          | 93.70          | $1\frac{1}{8}$   |
| $1\frac{1}{4}$   | 75.62                       | 81.44         | 87.16          | 93.09          | 98.91          | 104.7          | 110.5          | 116.4          | 122.2          | 128.0          | $1\frac{1}{4}$   |

## METAL SHEATHING.

Is usually made in sheets of the following weights and sizes:—

|                                    |       |       |       |
|------------------------------------|-------|-------|-------|
| Length in inches . . . . .         | 48    | 48    | 48    |
| Breadth " . . . . .                | 20    | 14    | 14    |
| Thickness " . . . . .              | .025  | .025  | .044  |
| Weight in lbs. per square foot . . | 1.125 | 1.75  | 2.00  |
| Weight in lbs. per sheet . . . . . | 7.50  | 11.67 | 18.25 |

Note.—One oz. of metal nails should be allowed for every 100 sheets.

TABLE OF WHITWORTH'S STANDARD TAPS AND DIES.

| No. of<br>Threads<br>per Inch | Old Sizes<br>(ins.) | New Sizes<br>of Taps<br>(ins.) | No. of<br>Threads<br>per Inch | Old Sizes<br>(ins.) | New Sizes<br>of Taps<br>(ins.) | No. of<br>Threads<br>per Inch | Old Sizes<br>(ins.) | New Sizes<br>of Taps<br>(ins.) | No. of<br>Threads<br>per Inch | Old Sizes<br>(ins.) | New Sizes<br>of Taps<br>(ins.) |
|-------------------------------|---------------------|--------------------------------|-------------------------------|---------------------|--------------------------------|-------------------------------|---------------------|--------------------------------|-------------------------------|---------------------|--------------------------------|
| 48                            | —                   | ·100                           | 14                            | —                   | ·475                           | 7                             | 1 $\frac{1}{2}$     | 1·125                          | 3 $\frac{1}{2}$               | 3                   | 3·000                          |
| 40                            | $\frac{1}{8}$       | ·125                           | 12                            | $\frac{1}{2}$       | ·500                           | 7                             | 1 $\frac{1}{2}$     | 1·250                          | 3 $\frac{1}{2}$               | 3                   | 3·250                          |
| 32                            | —                   | ·150                           | 12                            | —                   | ·525                           | 6                             | 1 $\frac{1}{2}$     | 1·375                          | 3 $\frac{1}{2}$               | 3                   | 3·500                          |
| 24                            | —                   | ·175                           | 12                            | —                   | ·550                           | 6                             | 1 $\frac{1}{2}$     | 1·500                          | 3 $\frac{1}{2}$               | 3                   | 3·750                          |
| 24                            | —                   | ·200                           | 12                            | —                   | ·575                           | 5                             | 1 $\frac{1}{2}$     | 1·625                          | 3                             | 4                   | 4·000                          |
| 24                            | —                   | ·225                           | 12                            | —                   | ·600                           | 5                             | 1 $\frac{1}{2}$     | 1·750                          | 2 $\frac{7}{8}$               | 4 $\frac{1}{2}$     | 4·250                          |
| 20                            | $\frac{1}{4}$       | ·250                           | 11                            | $\frac{3}{4}$       | ·625                           | 4 $\frac{1}{2}$               | 1 $\frac{1}{2}$     | 1·875                          | 2 $\frac{1}{2}$               | 4 $\frac{1}{2}$     | 4·500                          |
| 20                            | —                   | ·275                           | 11                            | —                   | ·650                           | 4 $\frac{1}{2}$               | 2                   | 2·000                          | 2 $\frac{1}{2}$               | 4 $\frac{1}{2}$     | 4·750                          |
| 18                            | —                   | ·300                           | 11                            | —                   | ·675                           | 4 $\frac{1}{2}$               | 2 $\frac{1}{2}$     | 2·125                          | 2 $\frac{1}{2}$               | 5                   | 5·000                          |
| 18                            | —                   | ·325                           | 11                            | —                   | ·700                           | 4                             | 2 $\frac{1}{2}$     | 2·250                          | 2 $\frac{1}{2}$               | 5 $\frac{1}{2}$     | 5·250                          |
| 18                            | —                   | ·350                           | 10                            | $\frac{3}{4}$       | ·750                           | 4                             | 2 $\frac{1}{2}$     | 2·375                          | 2 $\frac{1}{2}$               | 5 $\frac{1}{2}$     | 5·500                          |
| 16                            | $\frac{1}{4}$       | ·375                           | 10                            | —                   | ·800                           | 4                             | 2 $\frac{1}{2}$     | 2·500                          | 2 $\frac{1}{2}$               | 5 $\frac{1}{2}$     | 5·750                          |
| 16                            | —                   | ·400                           | 9                             | $\frac{7}{8}$       | ·875                           | 4                             | 2 $\frac{1}{2}$     | 2·625                          | 2 $\frac{1}{2}$               | 6                   | 6·000                          |
| 14                            | —                   | ·425                           | 9                             | —                   | ·900                           | 3 $\frac{1}{2}$               | 2 $\frac{1}{2}$     | 2·750                          | —                             | —                   | —                              |
| 14                            | —                   | ·450                           | 8                             | 1                   | 1·000                          | 3 $\frac{1}{2}$               | 2 $\frac{1}{2}$     | 2·875                          | —                             | —                   | —                              |

Note.—The angle of thread = 55°. Depth of thread =  $\frac{1}{4}$  of pitch bore—that is, deducting  $\frac{1}{8}$  for the quantity rounded off top and  $\frac{1}{8}$  off bottom.

TABLE OF WHITWORTH'S STANDARD HEXAGONAL NUTS AND BOLT-HEADS.

| Diameter<br>of Bolt | Distance<br>across<br>Flats | Thickness<br>of Nut | Thickness<br>of<br>Bolt-head | Diam. at<br>Bottom of<br>Thread | Diameter<br>of Bolt | Distance<br>across<br>Flats | Thickness<br>of Nut | Thickness<br>of<br>Bolt-head | Diam. at<br>Bottom of<br>Thread |
|---------------------|-----------------------------|---------------------|------------------------------|---------------------------------|---------------------|-----------------------------|---------------------|------------------------------|---------------------------------|
| Ins.                | Ins.                        | Ins.                | Ins.                         | Ins.                            | Ins.                | Ins.                        | Ins.                | Ins.                         | Ins.                            |
| $\frac{1}{8}$       | ·338                        | $\frac{1}{8}$       | ·1093                        | ·0929                           | 1 $\frac{1}{2}$     | 2·0483                      | 1 $\frac{1}{2}$     | 1·0937                       | 1·0670                          |
| $\frac{1}{4}$       | ·448                        | $\frac{1}{4}$       | ·1640                        | ·1341                           | 1 $\frac{1}{2}$     | 2·2146                      | 1 $\frac{1}{2}$     | 1·2031                       | 1·1615                          |
| $\frac{3}{8}$       | ·525                        | $\frac{3}{8}$       | ·2187                        | ·1850                           | 1 $\frac{1}{2}$     | 2·4134                      | 1 $\frac{1}{2}$     | 1·3125                       | 1·2868                          |
| $\frac{1}{2}$       | ·6014                       | $\frac{1}{2}$       | ·2734                        | ·2413                           | 1 $\frac{1}{2}$     | 2·5763                      | 1 $\frac{1}{2}$     | 1·4218                       | 1·3688                          |
| $\frac{5}{8}$       | ·7094                       | $\frac{5}{8}$       | ·3281                        | ·2949                           | 1 $\frac{1}{2}$     | 2·7578                      | 1 $\frac{1}{2}$     | 1·5312                       | 1·4938                          |
| $\frac{3}{4}$       | ·8204                       | $\frac{3}{4}$       | ·3828                        | ·3460                           | 1 $\frac{1}{2}$     | 3·0183                      | 1 $\frac{1}{2}$     | 1·6406                       | 1·5904                          |
| $\frac{7}{8}$       | ·9191                       | $\frac{7}{8}$       | ·4375                        | ·3932                           | 2                   | 3·1491                      | 2                   | 1·7500                       | 1·7154                          |
| 1                   | 1·0110                      | 1                   | ·4921                        | ·4557                           | 2 $\frac{1}{2}$     | 3·3370                      | 2 $\frac{1}{2}$     | 1·8593                       | 1·8404                          |
| 1 $\frac{1}{8}$     | 1·1010                      | 1 $\frac{1}{8}$     | ·5468                        | ·5085                           | 2 $\frac{1}{2}$     | 3·5460                      | 2 $\frac{1}{2}$     | 1·9687                       | 1·9298                          |
| 1 $\frac{1}{4}$     | 1·2011                      | 1 $\frac{1}{4}$     | ·6015                        | ·5710                           | 2 $\frac{1}{2}$     | 3·7500                      | 2 $\frac{1}{2}$     | 2·0781                       | 2·0548                          |
| 1 $\frac{3}{8}$     | 1·3012                      | 1 $\frac{3}{8}$     | ·6562                        | ·6219                           | 2 $\frac{1}{2}$     | 3·8940                      | 2 $\frac{1}{2}$     | 2·1875                       | 2·1798                          |
| 1 $\frac{1}{2}$     | 1·4000                      | 1 $\frac{1}{2}$     | ·7100                        | ·6844                           | 2 $\frac{1}{2}$     | 4·0490                      | 2 $\frac{1}{2}$     | 2·2968                       | 2·3048                          |
| 1 $\frac{3}{4}$     | 1·4788                      | 1 $\frac{3}{4}$     | ·7636                        | ·7327                           | 2 $\frac{1}{2}$     | 4·1810                      | 2 $\frac{1}{2}$     | 2·4062                       | 2·3840                          |
| 1 $\frac{7}{8}$     | 1·5745                      | 1 $\frac{7}{8}$     | ·8203                        | ·7952                           | 2 $\frac{1}{2}$     | 4·3456                      | 2 $\frac{1}{2}$     | 2·5156                       | 2·5090                          |
| 1                   | 1·6707                      | 1                   | ·8750                        | ·8399                           | 3                   | 4·5310                      | 3                   | 2·6250                       | 2·6340                          |
| 1 $\frac{1}{8}$     | 1·8605                      | 1 $\frac{1}{8}$     | ·9843                        | ·9420                           | —                   | —                           | —                   | —                            | —                               |



TABLE OF THE SIZES, WEIGHTS, &amp;c., OF ADMIRALTY TANKS.

| COMMON WATER-TANKS. |        |     |       |     |       |     |          |          |        |      |      |     |
|---------------------|--------|-----|-------|-----|-------|-----|----------|----------|--------|------|------|-----|
| No.                 | Height |     | Width |     | Depth |     | Capacity |          | Weight |      |      | No. |
|                     | Ft.    | In. | Ft.   | In. | Ft.   | In. | Gals.    | Cub. Ft. | Cwt.   | Qrs. | Lbs. |     |
| 1                   | 4      | 0   | 4     | 0   | 6     | 0   | 600      | 101      | 10     | 2    | 12   | 1   |
| 1A                  | 4      | 0   | 2     | 0   | 6     | 0   | 300      | 51       | 7      | 0    | 25   | 1A  |
| 4                   | 4      | 0   | 4     | 0   | 5     | 0   | 500      | 85       | 9      | 0    | 2    | 4   |
| 4A                  | 4      | 0   | 2     | 0   | 5     | 0   | 250      | 42       | 6      | 0    | 15   | 4A  |
| 7                   | 4      | 0   | 4     | 0   | 4     | 0   | 400      | 68       | 7      | 1    | 7    | 7   |
| 7A                  | 4      | 0   | 2     | 0   | 4     | 0   | 200      | 35       | 5      | 0    | 6    | 7A  |
| 10                  | 4      | 0   | 3     | 3   | 3     | 2   | 200      | 35       | 4      | 2    | 17   | 10  |
| 10A                 | 4      | 0   | 1     | 7   | 3     | 2   | 100      | 18       | 3      | 1    | 5    | 10A |
| 12                  | 4      | 0   | 4     | 0   | 3     | 0   | 300      | 51       | 6      | 0    | 9    | 12  |
| 13                  | 4      | 0   | 4     | 0   | 2     | 0   | 200      | 34       | 4      | 3    | 23   | 13  |
| 14                  | 4      | 0   | 2     | 7   | 1     | 7   | 100      | 17       | 3      | 1    | 0    | 14  |

BULK WATER TANKS.

| No. | Dimensions |     |     |     |     | Capacity |       | Weight   |      | No. |      |      |
|-----|------------|-----|-----|-----|-----|----------|-------|----------|------|-----|------|------|
|     | A          |     | B   |     | C   |          | Gals. | Cub. Ft. | Cwt. |     | Qrs. | Lbs. |
|     | Ft.        | In. | Ft. | In. | Ft. | In.      |       |          |      |     |      |      |
| 2   | 4          | 0   | 6   | 0   | 5   | 1        | 575   | 96       | 10   | 0   | 22   | 2    |
| 2A  | 2          | 0   | 6   | 0   | 5   | 1        | 287   | 49       | 6    | 3   | 15   | 2A   |
| 3   | 4          | 0   | 6   | 0   | 4   | 1        | 510   | 87       | 9    | 0   | 18   | 3    |
| 3A  | 2          | 0   | 6   | 0   | 4   | 1        | 255   | 44       | 6    | 2   | 0    | 3A   |
| 5   | 4          | 0   | 5   | 0   | 4   | 0        | 475   | 80       | 8    | 2   | 5    | 5    |
| 5A  | 2          | 0   | 5   | 0   | 4   | 0        | 237   | 41       | 5    | 2   | 17   | 5A   |
| 6   | 4          | 0   | 5   | 0   | 3   | 0        | 410   | 68       | 8    | 0   | 0    | 6    |
| 6A  | 2          | 0   | 5   | 0   | 3   | 0        | 205   | 35       | 5    | 1   | 24   | 6A   |
| 8   | 4          | 0   | 4   | 0   | 3   | 1        | 375   | 64       | 6    | 3   | 26   | 8    |
| 8A  | 2          | 0   | 4   | 0   | 3   | 1        | 187   | 32       | 4    | 3   | 0    | 8A   |
| 9   | 4          | 0   | 4   | 0   | 2   | 0        | 310   | 54       | 6    | 1   | 6    | 9    |
| 9A  | 2          | 0   | 4   | 0   | 2   | 0        | 155   | 27       | 4    | 1   | 7    | 9A   |
| 11  | 3          | 2   | 3   | 2   | 1   | 8        | 110   | 20       | 3    | 1   | 7    | 11   |

BREAD TANKS.

| No. | Hght. | Wdth. | Dpth. | Wgt. |
|-----|-------|-------|-------|------|
|     | Ft.   | In.   | Ft.   | In.  |
|     | Ft.   | In.   | Ft.   | In.  |
| A   | 2     | 0     | 3     | 2    |
| B   | 2     | 0     | 3     | 2    |
| C   | 1     | 6     | 2     | 0    |
| D   | 1     | 0     | 1     | 3    |

PAINT CISTERNS.

| No. | Hght. | Wdth. | Dpth. | Wgt. |
|-----|-------|-------|-------|------|
|     | Ft.   | In.   | Ft.   | In.  |
|     | Ft.   | In.   | Ft.   | In.  |
| A   | 1     | 6     | 1     | 11   |
| B   | 1     | 6     | 1     | 8    |
| C   | 1     | 3     | 1     | 8    |
| D   | 1     | 0     | 1     | 0    |

OIL CISTERNS.

| No. | Hght. | Wdth. | Dpth. | Wgt. |
|-----|-------|-------|-------|------|
|     | Ft.   | In.   | Ft.   | In.  |
|     | Ft.   | In.   | Ft.   | In.  |
| A   | 1     | 6     | 3     | 0    |
| B   | 1     | 6     | 2     | 2    |
| C   | 1     | 3     | 2     | 3    |
| D   | 1     | 4     | 1     | 3    |

FIG. 162.

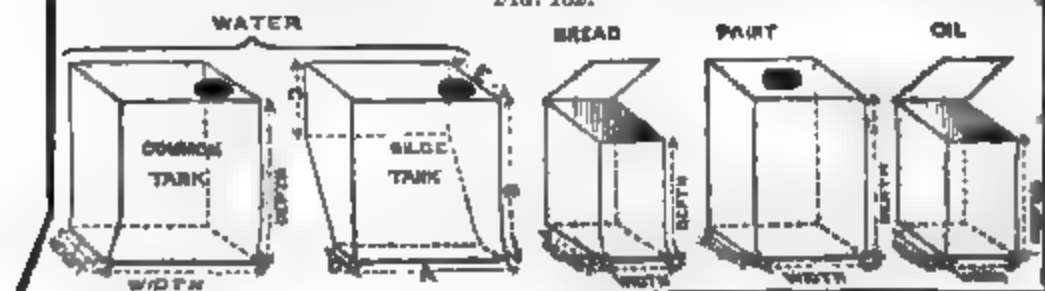


TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE.

| CIRCLE.               | 1        | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9         |
|-----------------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| $\pi$                 | 3.1416   | 6.2832    | 9.4248    | 12.5664   | 15.7080   | 18.8496   | 21.9912   | 25.1328   | 28.2744   |
| $\pi \div 4$          | .7854    | 1.5708    | 2.3562    | 3.1416    | 3.9270    | 4.7124    | 5.4978    | 6.2832    | 7.0686    |
| $\pi \div 6$          | .5236    | 1.0472    | 1.5708    | 2.0944    | 2.6180    | 3.1416    | 3.6652    | 4.1888    | 4.7124    |
| $\pi \div 180$        | .01745   | .03490    | .05235    | .06980    | .08725    | .10470    | .12215    | .13960    | .15705    |
| $\pi \div 200$        | .015708  | .031416   | .047124   | .062832   | .078540   | .094248   | .109956   | .125664   | .141372   |
| $\pi \sqrt{2}$        | 4.44288  | 8.88576   | 13.32864  | 17.77152  | 22.21440  | 26.65728  | 31.10016  | 35.54304  | 39.98592  |
| $\pi \sqrt{1 \div 2}$ | 2.22144  | 4.44288   | 6.66432   | 8.88576   | 11.10720  | 13.32864  | 15.55008  | 17.77152  | 19.99296  |
| $\sqrt{\pi}$          | 1.772454 | 3.544908  | 5.317362  | 7.089816  | 8.862270  | 10.634724 | 12.407178 | 14.179632 | 15.952086 |
| $\sqrt{\pi \div 4}$   | .886227  | 1.772454  | 2.658681  | 3.544908  | 4.431135  | 5.317362  | 6.203589  | 7.089816  | 7.976043  |
| $\sqrt{1 \div \pi}$   | .5642    | 1.1284    | 1.6926    | 2.2568    | 2.8210    | 3.3852    | 3.9494    | 4.5136    | 5.0778    |
| $\sqrt{1 \div 2}$     | .707107  | 1.414214  | 2.121321  | 2.828428  | 3.534435  | 4.242642  | 4.949749  | 5.656856  | 6.363963  |
| $\sqrt{2}$            | 1.41422  | 2.82844   | 4.24266   | 5.65688   | 7.07110   | 8.48532   | 9.89954   | 11.31376  | 12.72798  |
| $\sqrt{6 \div \pi}$   | 1.240701 | 2.481402  | 3.722103  | 4.962804  | 6.203505  | 7.444206  | 8.684907  | 9.925608  | 11.166309 |
| $\sqrt{\pi \div 6}$   | .805996  | 1.611992  | 2.417988  | 3.223984  | 4.029980  | 4.835976  | 5.641972  | 6.447968  | 7.253964  |
| $\sqrt{36 \pi}$       | 4.83598  | 9.67196   | 14.50794  | 19.34392  | 24.17990  | 29.01588  | 33.85186  | 38.68784  | 43.52382  |
| $2 \sqrt{\pi}$        | 3.54491  | 7.08982   | 10.63473  | 14.17964  | 17.72455  | 21.26946  | 24.81437  | 28.35928  | 31.90419  |
| $2 \sqrt{1 \div \pi}$ | 1.12838  | 2.25676   | 3.38514   | 4.51352   | 5.64190   | 6.77028   | 7.89866   | 9.02704   | 10.15542  |
| $1 \div \pi$          | .31831   | .63662    | .95493    | 1.27324   | 1.59155   | 1.90986   | 2.22817   | 2.54648   | 2.86479   |
| $1 \div \sqrt{3}$     | .5773502 | 1.1547004 | 1.7320506 | 2.3094008 | 2.8867510 | 3.4641012 | 4.0414514 | 4.6188016 | 5.1961518 |
| $180 \div \pi$        | 57.29578 | 114.59156 | 171.88734 | 239.18312 | 296.47890 | 343.77468 | 401.07046 | 458.36624 | 515.66202 |
| $200 \div \pi$        | 63.662   | 127.324   | 190.986   | 254.648   | 318.310   | 381.972   | 445.634   | 509.296   | 572.958   |
| $2\pi$                | 6.2832   | 12.5664   | 18.8496   | 25.1328   | 31.4160   | 37.6992   | 43.9824   | 50.2656   | 56.5488   |
| $4\pi$                | 12.5664  | 25.1328   | 37.6992   | 50.2656   | 62.8320   | 75.3984   | 87.9648   | 100.5312  | 113.0976  |
| $36\pi$               | 113.0973 | 226.1946  | 339.2919  | 452.3892  | 565.4865  | 678.5838  | 791.6811  | 904.7784  | 1017.8757 |
| $4\pi \div 3$         | 4.18879  | 8.37758   | 12.56637  | 16.75516  | 20.94395  | 25.13274  | 29.32153  | 33.51032  | 37.69911  |

Note.—For the more exact value and the significations of the constants in this table see 'Properties of the Circle.'

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (continued).

|                             | 1      | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |
|-----------------------------|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| GRAVITY.                    |        |         |         |         |         |         |         |         |         |
| $g$                         | 32.2   | 64.4    | 96.6    | 128.8   | 161.0   | 193.2   | 225.4   | 257.6   | 289.8   |
| $g+2$                       | 16.1   | 32.2    | 48.3    | 64.4    | 80.5    | 96.6    | 112.7   | 128.8   | 144.9   |
| $g+4$                       | 8.05   | 16.10   | 24.15   | 32.20   | 40.25   | 48.30   | 56.35   | 64.40   | 72.45   |
| $1+g$                       | .08106 | .06212  | .09818  | .12424  | .15530  | .18636  | .21742  | .24848  | .27954  |
| $1+2g$                      | .01553 | .03106  | .04659  | .06212  | .07765  | .09318  | .10871  | .12424  | .13977  |
| $2g$                        | 64.4   | 128.8   | 193.2   | 257.6   | 322.0   | 386.4   | 450.8   | 515.2   | 579.6   |
| $\sqrt{2g}$                 | 8.025  | 16.050  | 24.075  | 32.100  | 40.125  | 48.150  | 56.175  | 64.200  | 72.225  |
| LENGTH.                     |        |         |         |         |         |         |         |         |         |
| Miles = Austrian meiles x   | 4.7142 | 9.4284  | 14.1426 | 18.8568 | 23.5710 | 28.2852 | 32.9994 | 37.7136 | 42.4278 |
| Austrian meiles = miles x   | .21212 | .42424  | .63636  | .84848  | 1.06060 | 1.27272 | 1.48484 | 1.69696 | 1.9098  |
| Miles = French kilomètres x | .62138 | 1.24276 | 1.86414 | 2.48552 | 3.10690 | 3.72828 | 4.34966 | 4.97104 | 5.59242 |
| French kilomètres = miles x | 1.6093 | 3.2186  | 4.8279  | 6.4372  | 8.0465  | 9.6558  | 11.2651 | 12.8744 | 14.4837 |
| Miles = German meiles x     | 4.6807 | 9.3614  | 14.0421 | 18.7228 | 23.4035 | 28.0842 | 32.7649 | 37.4456 | 42.1263 |
| German meiles = miles x     | .21364 | .42728  | .64092  | .85456  | 1.06820 | 1.28184 | 1.49548 | 1.70912 | 1.92276 |
| Miles = Russian versts x    | .66288 | 1.32576 | 1.98864 | 2.65152 | 3.31440 | 3.97728 | 4.64016 | 5.30304 | 5.96592 |
| Russian versts = miles x    | 1.5086 | 3.0172  | 4.5258  | 6.0344  | 7.5430  | 9.0516  | 10.5602 | 12.0688 | 13.5774 |
| Miles = Swedish miles x     | 6.6420 | 13.2840 | 19.9260 | 26.5680 | 33.2100 | 39.8520 | 46.4940 | 53.1360 | 59.7780 |
| Swedish miles = miles x     | .15056 | .30112  | .45168  | .60224  | .75280  | .90336  | 1.05392 | 1.20448 | 1.35504 |
| Miles = Admiralty knots x   | 1.1515 | 2.3030  | 3.4545  | 4.6060  | 5.7575  | 6.9090  | 8.0605  | 9.2120  | 10.3635 |
| Admiralty knots = miles x   | .83842 | 1.73684 | 2.60526 | 3.47368 | 4.34210 | 5.21052 | 6.07894 | 6.94736 | 7.81578 |
| Miles = nautical miles x    | 1.1527 | 2.30547 | 3.4581  | 4.6108  | 5.7635  | 6.9162  | 8.0689  | 9.2216  | 10.3743 |
| Nautical miles = miles x    | .86753 | 1.73506 | 2.60259 | 3.47012 | 4.33765 | 5.20518 | 6.07271 | 6.94024 | 7.80777 |
| Miles = yards x             | .00057 | .00114  | .00171  | .00228  | .00285  | .00342  | .00399  | .00456  | .00513  |
| Yards = miles x             | 1760.0 | 3520.0  | 5280.0  | 7040.0  | 8800.0  | 10560.0 | 12320.0 | 14080.0 | 15840.0 |
| Miles = feet x              | .00019 | .00038  | .00057  | .00076  | .00095  | .00114  | .00133  | .00152  | .00171  |
| Feet = miles x              | 5280.0 | 10560.0 | 15840.0 | 21120.0 | 26400.0 | 31680.0 | 36960.0 | 42240.0 | 47520.0 |

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (continued).

| LENGTH (concluded).            | 1         | 2         | 3         | 4          | 5          | 6          | 7          | 8          | 9          |
|--------------------------------|-----------|-----------|-----------|------------|------------|------------|------------|------------|------------|
| Feet = Austrian fusa .         | 1-0871    | 2-0742    | 3-1113    | 4-1484     | 5-1855     | 6-2226     | 7-2597     | 8-2968     | 9-3339     |
| Austrian fusa = feet .         | ·96424    | 1-89248   | 2-88872   | 3-78496    | 4-78120    | 5-67744    | 6-62368    | 7-56992    | 8-51616    |
| Feet = French mètres .         | 3-2809    | 6-5618    | 9-8427    | 13-1236    | 16-4045    | 19-6854    | 22-9663    | 26-2472    | 29-5281    |
| French mètres = feet .         | ·30480    | ·60960    | ·91440    | 1-21920    | 1-52400    | 1-82880    | 2-13360    | 2-43840    | 2-74320    |
| Feet = German fusa .           | 1-0298    | 2-0596    | 3-0894    | 4-1192     | 5-1490     | 6-1788     | 7-2086     | 8-2384     | 9-2682     |
| German fusa = feet .           | ·97111    | 1-94222   | 2-91333   | 3-88444    | 4-85555    | 5-82666    | 6-79777    | 7-76888    | 8-73999    |
| Feet = Swedish fots .          | ·97420    | 1-94840   | 2-92260   | 3-89680    | 4-87100    | 5-84520    | 6-81940    | 7-79360    | 8-76780    |
| Swedish fots = feet .          | 1-0266    | 2-0530    | 3-0795    | 4-1060     | 5-1325     | 6-1590     | 7-1855     | 8-2120     | 9-2385     |
| SQUARE MEASURE.                |           |           |           |            |            |            |            |            |            |
| Acres = sq. miles .            | 640       | 1280      | 1920      | 2560       | 3200       | 3840       | 4480       | 5120       | 5760       |
| Sq. miles = acres .            | ·0015625  | ·0031250  | ·0046875  | ·0062500   | ·0078125   | ·0093750   | ·0109375   | ·0125000   | ·0140625   |
| Acres = French ares .          | ·0247111  | ·0494222  | ·0741333  | ·0988444   | ·1235555   | ·1482666   | ·1729777   | ·1976888   | ·2223999   |
| French ares = acres .          | 40-46-82  | 80-93564  | 121-40346 | 161-87128  | 202-33910  | 242-80692  | 283-27474  | 323-74256  | 364-21038  |
| Acres = sq. yards .            | ·00090461 | ·00041822 | ·00061883 | ·00082644  | ·00103405  | ·00124166  | ·00144927  | ·00165688  | ·00186449  |
| Sq. yards = acres .            | 4-840     | 9-680     | 14-520    | 19-360     | 24-200     | 29-040     | 33-880     | 38-720     | 43-560     |
| Sq. miles = French ares .      | ·0000386  | ·0000772  | ·0001158  | ·0001544   | ·0001930   | ·0002316   | ·0002702   | ·0003088   | ·0003474   |
| French ares = sq. miles .      | 25-859-41 | 51-718-82 | 77-698-23 | 103-597-64 | 129-497-05 | 155-396-46 | 181-295-87 | 207-195-28 | 233-094-69 |
| Sq. miles = sq. yards .        | ·00000032 | ·00000064 | ·00000096 | ·00000128  | ·00000160  | ·00000192  | ·00000224  | ·00000256  | ·00000288  |
| Sq. yards = sq. miles .        | 3097-600  | 6195-200  | 9292-800  | 12389-400  | 15486-000  | 18582-600  | 21679-200  | 24780-800  | 27877-400  |
| Sq. feet = sq. inches .        | ·0069444  | ·0138888  | ·0208332  | ·0277776   | ·0347220   | ·0416664   | ·0486108   | ·0555552   | ·0624996   |
| Sq. inches = sq. feet .        | 144       | 288       | 432       | 576        | 720        | 864        | 1008       | 1152       | 1296       |
| Sq. feet = Austrian sq. fusa . | 1-0755    | 2-1510    | 3-2265    | 4-3020     | 5-3775     | 6-4530     | 7-5285     | 8-6040     | 9-6795     |
| Austrian sq. fusa = sq. feet . | 9-2977    | 1-85954   | 2-78931   | 3-71908    | 4-64885    | 5-57862    | 6-50839    | 7-43816    | 8-36793    |
| Sq. feet = French ares .       | 107-6-410 | 2152-820  | 3229-230  | 4305-640   | 5382-050   | 6458-460   | 7534-870   | 8611-280   | 9687-690   |
| French ares = sq. feet .       | ·000929   | ·001858   | ·002787   | ·003716    | ·004645    | ·005574    | ·006503    | ·007432    | ·008361    |

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (continued).

| Sq. Measures (continued)     | 1        | 2        | 3        | 4        | 5        | 6        | 7        | '8       | 9        |
|------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Sq. feet = German sq. fuss   | 1-0605   | 2-1210   | 3-1815   | 4-2420   | 5-3025   | 6-3630   | 7-4235   | 8-4840   | 9-5445   |
| German sq. fuss = sq. feet   | 9-431    | 1-8862   | 2-8293   | 3-7724   | 4-7155   | 5-6586   | 6-6017   | 7-5448   | 8-4879   |
| Sq. feet = Swedish sq. fots  | 9-491    | 1-8982   | 2-8473   | 3-7964   | 4-7455   | 5-6946   | 6-6437   | 7-5928   | 8-5419   |
| Swedish sq. fots = sq. feet  | 1-0537   | 2-1074   | 3-1611   | 4-2148   | 5-2685   | 6-3222   | 7-3759   | 8-4296   | 9-4833   |
| SOLID MEASURES               |          |          |          |          |          |          |          |          |          |
| Cu. yards = cu. feet         | 0-07037  | 0-74074  | 1-11111  | 1-48148  | 1-85185  | 2-22222  | 2-59259  | 2-96296  | 3-33333  |
| Cu. feet = cu. yards         | 27       | 54       | 81       | 108      | 135      | 162      | 189      | 216      | 243      |
| Cu. yards = cu. inches       | 0-000214 | 0-000428 | 0-000642 | 0-000856 | 0-001070 | 0-001284 | 0-001498 | 0-001712 | 0-001926 |
| Cu. inches = cu. yards       | 46556    | 93112    | 139668   | 186334   | 232980   | 279636   | 326292   | 372948   | 419604   |
| Cu. yards = French stères    | 1-808    | 2-616    | 3-924    | 5-232    | 6-540    | 7-848    | 9-156    | 10-464   | 11-772   |
| French stères = cu. yards    | 0-5545   | 1-05290  | 1-55135  | 2-04980  | 2-54825  | 3-04670  | 3-54515  | 4-04360  | 4-54205  |
| Cu. feet = cu. inches        | 0-00579  | 0-01158  | 0-01737  | 0-02316  | 0-02895  | 0-03474  | 0-04053  | 0-04632  | 0-05211  |
| Cu. inches = cu. feet        | 1728     | 3456     | 5184     | 6912     | 8640     | 10368    | 12096    | 13824    | 15552    |
| Cu. feet = Austrian cu. fuss | 1-11548  | 2-23096  | 3-34644  | 4-46192  | 5-57740  | 6-69288  | 7-80836  | 8-92384  | 10-03932 |
| Austrian cu. fuss = cu. feet | 89651    | 1-79302  | 2-68953  | 3-58604  | 4-48255  | 5-37906  | 6-27557  | 7-17208  | 8-06859  |
| Cu. feet = French stères     | 35-3156  | 70-6312  | 105-9468 | 141-2624 | 176-5780 | 211-8936 | 247-2092 | 282-5248 | 317-8404 |
| French stères = cu. feet     | 0-02832  | 0-05664  | 0-08496  | 0-11328  | 0-14160  | 0-16992  | 0-19824  | 0-22656  | 0-25488  |
| Cu. feet = German cu. fuss   | 1-0921   | 2-1842   | 3-2763   | 4-3684   | 5-4605   | 6-5526   | 7-6447   | 8-7368   | 9-8289   |
| German cu. fuss = cu. feet   | 9159     | 1-8316   | 2-7474   | 3-6632   | 4-5790   | 5-4948   | 6-4106   | 7-3264   | 8-2422   |
| Cu. feet = Swedish cu. fots  | 9246     | 1-8492   | 2-7738   | 3-6984   | 4-6230   | 5-5476   | 6-4722   | 7-3968   | 8-3214   |
| Swedish cu. fots = cu. feet  | 1-0816   | 2-1632   | 3-2448   | 4-3264   | 5-4080   | 6-4896   | 7-5712   | 8-6528   | 9-7344   |
| Cu. inches = French stères   | 61025-4  | 122050-8 | 183076-2 | 244101-6 | 305127-0 | 366152-4 | 427177-8 | 488203-2 | 549228-6 |
| French stères = cu. inches   | 0-000164 | 0-000328 | 0-000492 | 0-000656 | 0-000820 | 0-000984 | 0-001148 | 0-001312 | 0-001476 |
| Cu. ins. = Austrian cu. Zoll | 1-11548  | 2-23096  | 3-34644  | 4-46192  | 5-57740  | 6-69288  | 7-80836  | 8-92384  | 10-03932 |
| Austrian cu. Zoll = cu. ins. | 89651    | 1-79302  | 2-68953  | 3-58604  | 4-48255  | 5-37906  | 6-27557  | 7-17208  | 8-06859  |

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (continued).

| CAPACITY.                  | 1         | 2         | 3         | 4         | 5         | 6         | 7         | 8         | 9         |
|----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Cu. feet = quarters        | 10-2694   | 20-5388   | 30-8082   | 41-0776   | 51-8470   | 61-6164   | 71-8858   | 82-1552   | 92-4246   |
| Quarters = cu. feet        | 0-97201   | 1-94402   | 2-91603   | 3-88804   | 4-86005   | 5-83206   | 6-80407   | 7-77608   | 8-74809   |
| Cu. feet = bushels         | 1-2887    | 2-5674    | 3-8511    | 5-1348    | 6-4185    | 7-7022    | 8-9859    | 10-2696   | 11-5533   |
| Bushels = cu. feet         | 77-8998   | 1-557996  | 2-336994  | 3-115992  | 3-894990  | 4-673988  | 5-452986  | 6-231984  | 7-010982  |
| Cu. feet = French litres   | 0-353156  | 0-706312  | 1-059468  | 1-412624  | 1-765780  | 2-118936  | 2-472092  | 2-825248  | 3-178404  |
| French litres = cu. feet   | 27-8161   | 54-6322   | 81-9483   | 109-2644  | 136-5805  | 163-8966  | 191-2127  | 218-5288  | 245-8449  |
| Cu. feet = gallons         | 1-60459   | 3-20918   | 4-81377   | 6-41836   | 8-02295   | 9-62754   | 1-123213  | 1-283672  | 1-444131  |
| Gallons = cu. feet         | 6-23210   | 12-46420  | 18-69630  | 24-92840  | 31-16050  | 37-39260  | 43-62470  | 49-85680  | 56-08890  |
| Cu. inches = gallons       | 277-274   | 554-548   | 831-822   | 1109-096  | 1386-370  | 1663-644  | 1940-918  | 2218-192  | 2495-466  |
| Gallons = cu. inches       | 0-0036065 | 0-0072130 | 0-0108195 | 0-0144260 | 0-0180325 | 0-0216390 | 0-0252455 | 0-0288520 | 0-0324585 |
| Cu. inches = French litres | 61-0254   | 122-0508  | 183-0762  | 244-1016  | 305-1270  | 366-1524  | 427-1778  | 488-2032  | 549-2286  |
| French litres = cu. inches | 0-163866  | 0-327732  | 0-491598  | 0-655464  | 0-819330  | 0-983196  | 1-147062  | 1-310928  | 1-474794  |
| Cu. inches = quarts        | 69-3185   | 138-6370  | 207-9555  | 277-2740  | 346-5925  | 415-9110  | 485-2295  | 554-5480  | 623-8665  |
| Quarts = cu. inches        | 0-14424   | 0-28848   | 0-43272   | 0-57696   | 0-72120   | 0-86544   | 1-00968   | 1-15392   | 1-29816   |
| Cu. inches = pints         | 34-6592   | 69-3184   | 103-9776  | 138-6368  | 173-2960  | 207-9552  | 242-6144  | 277-2736  | 311-9328  |
| Pints = cu. inches         | 0-28848   | 0-57696   | 0-86544   | 1-15392   | 1-44240   | 1-73088   | 2-01936   | 2-30784   | 2-59632   |
| Bushels = Austrian metzen  | 1-6918    | 3-3836    | 5-0754    | 6-7672    | 8-4590    | 10-1508   | 11-8426   | 13-5344   | 15-2262   |
| Austrian metzen = bushels  | 59-1086   | 1-182172  | 1-773258  | 2-364344  | 2-955430  | 3-546516  | 4-137602  | 4-728688  | 5-319774  |
| Bushels = French litres    | 1-69180   | 3-38360   | 5-07540   | 6-76720   | 8-45900   | 10-15080  | 11-84260  | 13-53440  | 15-22620  |
| French litres = bushels    | 36-3487   | 72-6974   | 109-0461  | 145-3948  | 181-7435  | 218-0922  | 254-4409  | 290-7896  | 327-1383  |
| Bushels = German scheffels | 1-5121    | 3-0242    | 4-5363    | 6-0484    | 7-5605    | 9-0726    | 10-5847   | 12-0968   | 13-6089   |
| German scheffels = bushels | 66-1331   | 1-322662  | 1-983993  | 2-645324  | 3-306655  | 3-967986  | 4-629317  | 5-290648  | 5-951979  |
| Bushels = Russian pajaks   | 1-4426    | 2-8852    | 4-3278    | 5-7704    | 7-2130    | 8-6556    | 10-0982   | 11-5408   | 12-9834   |
| Russian pajaks = bushels   | 69-3191   | 1-386383  | 2-079582  | 2-772776  | 3-465970  | 4-159164  | 4-852358  | 5-545552  | 6-238746  |
| Bushels = Swedish spans    | 2-0150    | 4-0300    | 6-0450    | 8-0600    | 10-0750   | 12-0900   | 14-1050   | 16-1200   | 18-1350   |
| Swedish spans = bushels    | 49-6278   | 99-2556   | 1-488884  | 1-985112  | 2-481390  | 2-977668  | 3-473946  | 3-970224  | 4-466502  |

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (continued).

| CAPACITY (concluded).                |         |          |          |          |          |          |          |          |          |
|--------------------------------------|---------|----------|----------|----------|----------|----------|----------|----------|----------|
|                                      | 1       | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        |
| Gallons = Austrian Viertel . . .     | 8.1148  | 6.3286   | 9.8429   | 12.4572  | 15.5715  | 18.6858  | 21.8001  | 24.9144  | 28.0287  |
| Austrian Viertel = gallons . . .     | .321099 | .642198  | .963297  | 1.284396 | 1.605495 | 1.926594 | 2.247693 | 2.568792 | 2.889891 |
| Gallons = French litres . . .        | .220097 | .440194  | .660291  | .880388  | 1.100486 | 1.320583 | 1.540679 | 1.760776 | 1.980873 |
| French litres = gallons . . .        | 4.451   | 8.902    | 13.353   | 17.804   | 22.255   | 26.706   | 31.157   | 35.608   | 40.059   |
| Gallons = German ankers . . .        | 7.559   | 15.118   | 22.677   | 30.236   | 37.795   | 45.354   | 52.913   | 60.472   | 68.031   |
| German ankers = gallons . . .        | .132298 | .264596  | .396894  | .529192  | .661490  | .793788  | .926086  | 1.058384 | 1.190682 |
| Gallons = Russian vedros . . .       | 2.7049  | 5.4098   | 8.1147   | 10.8196  | 13.5245  | 16.2294  | 18.9343  | 21.6392  | 24.3441  |
| Russian vedros = gallons . . .       | .3697   | .7394    | 1.1091   | 1.4788   | 1.8485   | 2.2182   | 2.5879   | 2.9576   | 3.3273   |
| Gallons = Swedish kannas . . .       | .5766   | 1.1532   | 1.7298   | 2.3064   | 2.8830   | 3.4596   | 4.0362   | 4.6128   | 5.1894   |
| Swedish kannas = gallons . . .       | 1.7678  | 3.5356   | 5.3034   | 7.0712   | 8.8390   | 10.6068  | 12.3746  | 14.1424  | 15.9102  |
| WEIGHT.                              |         |          |          |          |          |          |          |          |          |
| Avoir, lbs. = quarters . . .         | 28      | 56       | 84       | 112      | 140      | 168      | 196      | 224      | 252      |
| Quarters = avoird. lbs. . .          | .035714 | .071428  | .107142  | .142857  | .178571  | .214286  | .249999  | .285712  | .321428  |
| Avoir, lbs. = cwt. . .               | 112     | 224      | 336      | 448      | 560      | 672      | 784      | 896      | 1008     |
| Cwt. = avoird. lbs. . .              | .008929 | .017858  | .026787  | .035716  | .044645  | .053574  | .062503  | .071432  | .080361  |
| Avoir, lbs. = tons . . .             | 2240    | 4480     | 6720     | 8960     | 11200    | 13440    | 15680    | 17920    | 20160    |
| Tons = avoird. lbs. . .              | .000446 | .000892  | .001338  | .001784  | .002230  | .002676  | .003122  | .003568  | .004014  |
| Avoir, cwt. = pounds . . .           | 16      | 32       | 48       | 64       | 80       | 96       | 112      | 128      | 144      |
| Pounds = avoird. cwt. . .            | .0625   | .1250    | .1875    | .2500    | .3125    | .3750    | .4375    | .5000    | .5625    |
| Avoir, cwt. = quarters . . .         | 448     | 896      | 1344     | 1792     | 2240     | 2688     | 3136     | 3584     | 4032     |
| Quarters = avoird. cwt. . .          | .002232 | .004464  | .006696  | .008928  | .011160  | .013392  | .015624  | .017856  | .020088  |
| Avoir, lbs. = Austrian pfund . . .   | 1.2852  | 2.5704   | 3.8556   | 5.1408   | 6.4260   | 7.7112   | 9.0064   | 10.2916  | 11.5768  |
| Austrian pfund = avoird. lbs. . .    | .609596 | 1.219192 | 1.828788 | 2.438384 | 3.047980 | 3.657576 | 4.267172 | 4.876768 | 5.486364 |
| Avoir, lbs. = French kilograms . . . | 2.20462 | 4.40924  | 6.61386  | 8.81848  | 11.02310 | 13.22772 | 15.43234 | 17.63696 | 19.84158 |
| French kilograms = avoird. lbs. . .  | .453593 | .907186  | 1.360779 | 1.814372 | 2.267965 | 2.721558 | 3.175151 | 3.628744 | 4.082337 |

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS RELATING TO EACH UNIT UP TO NINE (continued).

| Weight (continued).               | 1      | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       |
|-----------------------------------|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| Avoir. lbs. = German pfunds.      | 1-0811 | 2-0622  | 3-0933  | 4-1344  | 5-1655  | 6-1966  | 7-2177  | 8-2488  | 9-2799  |
| German pfunds = avoird. lbs.      | 9-0864 | 1-9868  | 2-9063  | 3-8798  | 4-8192  | 5-8190  | 6-7888  | 7-7572  | 8-7966  |
| Avoird. lbs. = Russian funts.     | 9-0264 | 1-8628  | 2-7092  | 3-6106  | 4-5120  | 5-4184  | 6-3188  | 7-2212  | 8-1276  |
| Russian funts = avoird. lbs.      | 1-1078 | 2-2157  | 3-3235  | 4-4314  | 5-5392  | 6-6471  | 7-7550  | 8-8628  | 9-9707  |
| Avoird. lbs. = Swedish skappunds. | 9-876  | 1-8752  | 2-8128  | 3-7504  | 4-6880  | 5-6256  | 6-5632  | 7-5008  | 8-4384  |
| Swedish skappunds = avoird. lbs.  | 1-0665 | 2-1310  | 3-1965  | 4-2620  | 5-3275  | 6-3930  | 7-4585  | 8-5240  | 9-5895  |
| Tons = Austrian pfunds            | 9-0055 | 1-0117  | 2-0179  | 3-0241  | 4-0303  | 5-0365  | 6-0427  | 7-0489  | 8-0551  |
| Austrian pfunds = tons.           | 1-1134 | 2-2268  | 3-3402  | 4-4536  | 5-5670  | 6-6804  | 7-7938  | 8-9072  | 9-0206  |
| Tons = French kilograms           | 9-0000 | 1-0000  | 2-0000  | 3-0000  | 4-0000  | 5-0000  | 6-0000  | 7-0000  | 8-0000  |
| French kilograms = tons           | 1-0165 | 2-0330  | 3-0495  | 4-0660  | 5-0825  | 6-0990  | 7-1155  | 8-1320  | 9-1485  |
| Tons = German schuffpunds.        | 1-1519 | 2-3038  | 3-4557  | 4-6076  | 5-7595  | 6-9114  | 7-0633  | 8-2152  | 9-3671  |
| German schuffpunds = tons         | 6-6828 | 1-3357  | 2-6714  | 4-0071  | 5-3428  | 6-6785  | 8-0142  | 9-3499  | 10-6856 |
| Tons = Russian poods              | 4-8356 | 9-6712  | 1-4506  | 2-9012  | 4-3518  | 5-8024  | 7-2530  | 8-7036  | 10-1542 |
| Russian poods = tons.             | 2-0680 | 4-1360  | 6-2040  | 8-2720  | 10-3400 | 12-4080 | 14-4760 | 16-5440 | 18-6120 |
| Tons = Swedish skappunds          | 1-6742 | 3-3484  | 5-0226  | 6-6968  | 8-3710  | 10-0452 | 11-7194 | 13-3936 | 15-0678 |
| Swedish skappunds = tons          | 5-9727 | 11-9454 | 17-9181 | 23-8908 | 29-8635 | 35-8362 | 41-8089 | 47-7816 | 53-7543 |
| Weight of cast copper = cu. in.   | 2-5770 | 5-1540  | 7-7310  | 10-3080 | 12-8850 | 15-4620 | 18-0390 | 20-6160 | 23-1930 |
| " sheet "                         | 2-7778 | 5-5556  | 8-3334  | 11-1112 | 13-8890 | 16-6668 | 19-4446 | 22-2224 | 25-0002 |
| " cast brass "                    | 3-1182 | 6-2364  | 9-3546  | 12-4728 | 15-5910 | 18-7092 | 21-8274 | 24-9456 | 28-0638 |
| " sheet "                         | 3-1774 | 6-3548  | 9-5322  | 12-7096 | 15-8870 | 19-0644 | 22-2418 | 25-4192 | 28-5966 |
| " cast iron "                     | 3-0867 | 6-1734  | 9-2601  | 12-3468 | 15-4335 | 18-5202 | 21-6069 | 24-6936 | 27-7803 |
| " wrot. "                         | 3-0527 | 6-1054  | 9-1581  | 12-2108 | 15-2635 | 18-3162 | 21-3689 | 24-4216 | 27-4743 |
| " hard steel "                    | 2-8275 | 5-6550  | 8-4825  | 11-3100 | 14-1375 | 16-9650 | 19-7925 | 22-6200 | 25-4475 |
| " cast "                          | 2-8383 | 5-6766  | 8-5149  | 11-3532 | 14-1915 | 17-0298 | 19-8681 | 22-7064 | 25-5447 |
| " sheet lead "                    | 2-5420 | 5-0840  | 7-6260  | 10-1680 | 12-7100 | 15-2520 | 17-7940 | 20-3360 | 22-8780 |
| " cast zinc "                     | 2-6193 | 5-2386  | 7-8579  | 10-4772 | 13-1165 | 15-7558 | 18-3951 | 21-0344 | 23-6737 |
| " sheet "                         | 2-6100 | 5-2200  | 7-8300  | 10-4400 | 13-0600 | 15-6800 | 18-3000 | 20-9200 | 23-5400 |



TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (concluded).

| WEIGHT (concluded).                        |   | 1       | 2       | 3        | 4        | 5        | 6        | 7        | 8        | 9        |
|--|---|---------|---------|----------|----------|----------|----------|----------|----------|----------|
| Tons = French stères of sea water.         | × | .9914   | 1.9828  | 2.9742   | 3.9656   | 4.9570   | 5.9484   | 6.9398   | 7.9312   | 8.9226   |
| French stères of sea water = tons.         | × | 1.0086  | 2.0172  | 3.0258   | 4.0344   | 5.0430   | 6.0516   | 7.0602   | 8.0688   | 9.0774   |
| Tons = German cu. fuss of rain water       | × | .0304   | .0608   | .0912    | .1216    | .1520    | .1824    | .2128    | .2432    | .2736    |
| German cu. fuss of rain water = tons       | × | 32.8937 | 65.7874 | 98.6811  | 131.5748 | 164.4685 | 197.3622 | 230.2559 | 263.1496 | 296.0433 |
| Tons = German cu. fuss of sea water        | × | .03119  | .06238  | .09357   | .12476   | .15595   | .18714   | .21833   | .24952   | .28071   |
| German cu. fuss of sea water = tons        | × | 32.0602 | 64.1204 | 96.1806  | 128.2408 | 160.3010 | 192.3612 | 224.4214 | 256.4816 | 288.5418 |
| Tons = Swedish cu. fots of rain water      | × | .0284   | .0568   | .0852    | .1136    | .1420    | .1704    | .1988    | .2272    | .2556    |
| Swedish cu. fots of rain water = tons      | × | 35.267  | 70.534  | 105.801  | 141.068  | 176.335  | 211.602  | 246.869  | 282.136  | 317.408  |
| Tons = Swedish cu. fots of sea water       | × | .0299   | .0598   | .0897    | .1196    | .1495    | .1794    | .2093    | .2392    | .2691    |
| Swedish cu. fots of sea water = tons       | × | 34.374  | 68.748  | 103.122  | 137.496  | 171.870  | 206.244  | 240.618  | 274.992  | 309.366  |
| Lbs. = cubic feet of air.                  | . | .0755   | .1510   | .2265    | .8020    | .3775    | .4530    | .5285    | .6040    | .6795    |
| Cubic feet of air = lbs.                   | . | 13.2485 | 26.4970 | 39.7455  | 52.9940  | 66.2425  | 79.4910  | 92.7395  | 105.9880 | 119.2365 |
| Lbs. = cubic inches of air.                | . | 1.2077  | 2.4154  | 3.6231   | 4.8308   | 6.0385   | 7.2462   | 8.4539   | 9.6616   | 10.8693  |
| Cubic inches of air = lbs.                 | . | .82802  | 1.65604 | 2.48406  | 3.31208  | 4.14010  | 4.96812  | 5.79614  | 6.62416  | 7.45218  |
| Lbs. on sq. in. = kilograms on sq. centim. | × | 14.2231 | 28.4462 | 42.6693  | 56.8924  | 71.1155  | 85.3386  | 99.5617  | 113.7848 | 128.0079 |
| Kilogs. on sq. centim. = lbs. on sq. in.   | × | .07031  | .14062  | .21093   | .28124   | .35155   | .42186   | .49217   | .56248   | .63279   |
| MISCELLANEOUS NUMBERS.                     |   |         |         |          |          |          |          |          |          |          |
| Lgth. of secs. pendulum in ins., London.   | . | 39.1393 | 78.2786 | 117.4179 | 156.5572 | 195.6965 | 234.8358 | 273.9751 | 313.1144 | 352.2587 |
| " " " " Edinburgh                          | . | 39.1555 | 78.3110 | 117.4665 | 156.6220 | 195.7775 | 234.9330 | 274.0885 | 313.2440 | 352.3995 |
| " " " " Paris                              | . | 39.1293 | 78.2586 | 117.3879 | 156.5172 | 195.6465 | 234.7758 | 273.9051 | 313.0344 | 352.1637 |
| " " " " New York                           | . | 39.1012 | 78.2024 | 117.3086 | 156.4048 | 195.5060 | 234.6072 | 273.7084 | 312.8096 | 351.9108 |
| Force of gravity* in London, ft. per sec.  | . | 32.1908 | 64.3816 | 96.5724  | 128.7632 | 160.9540 | 193.1448 | 225.3356 | 257.5264 | 289.7172 |
| " " " " Edinburgh                          | . | 32.2041 | 64.4082 | 96.6128  | 128.8164 | 161.0205 | 193.2246 | 225.4287 | 257.6328 | 289.8369 |
| " " " " Paris                              | . | 32.1826 | 64.3652 | 96.5478  | 128.7304 | 160.9180 | 193.0956 | 225.2782 | 257.4608 | 289.6484 |
| " " " " New York                           | . | 32.1595 | 64.3190 | 96.4785  | 128.6880 | 160.7975 | 192.9570 | 225.1165 | 257.2760 | 289.4355 |

\* Gravity is generally taken at 32.2 as a mean to suit all degrees of latitude (see p. 147).



TABLE OF THE SIZES AND PITCHES OF RIVETS AS EMPLOYED IN 'H.M.S.' 'HERRONS' (continued).

| Description of Work                          | Thickness of Iron<br>(in Ins.)   | Breadth<br>of Lap<br>(in Ins.) | Pitch of<br>Rivets<br>(in Ins.)  | Diam. of<br>Rivets<br>(in Ins.) |
|--|--|--------------------------------|----------------------------------|---------------------------------|
| Longitudinals to angle irons on inner edges  | $8 \times 8 \times \frac{1}{4}$ to $\frac{3}{4}$ & $\frac{1}{2}$ plate                                 | —                              | 5 to 6                           | $\frac{1}{2}$                   |
| Butt straps to longitudinals*                | $\frac{3}{4}$ to $\frac{1}{2}$ plate, $\frac{1}{2}$ to $\frac{3}{4}$ "                                 | $8\frac{1}{2}$                 | $3\frac{1}{2}$                   | $\frac{1}{2}$                   |
| " " water-tight longitudinals*               | $\frac{3}{4}$ to $\frac{1}{2}$ "   | $8\frac{1}{2}$                 | $3\frac{1}{2}$                   | $\frac{1}{2}$                   |
| Inner bottom to continuous transverse frames | $5\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{16}$ to $\frac{1}{4}$ & $\frac{1}{2}$ "              | —                              | 6                                | $\frac{1}{2}$                   |
| " " edge strips                              | $\frac{1}{2}$ to $\frac{3}{4}$ plate, $\frac{1}{2}$ to $\frac{1}{4}$ "                                 | 5                              | 4                                | $\frac{1}{2}$                   |
| " " butt straps†                             | " "  | 9                              | 8                                | $\frac{1}{2}$                   |
| Transverse bulkheads to edge strips          | $4\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$ iron to $\frac{1}{2}$ "                          | $4\frac{1}{2}$                 | $3\frac{1}{2}$ to $4\frac{1}{2}$ | $\frac{1}{2}$                   |
| " " butt straps†                             | $\frac{1}{2}$ , $\frac{3}{4}$ , and $\frac{1}{2}$ plate  | —                              | $3\frac{1}{2}$                   | $\frac{1}{2}$                   |
| " " stiffeners                               | Same as plates   | $5\frac{1}{2}$                 | 5 to 6                           | $\frac{1}{2}$                   |
| " " inner bottom                             | $3\frac{1}{2} \times 3 \times \frac{1}{16}$ to $\frac{1}{4}$ , $\frac{1}{2}$ , and $\frac{3}{4}$ plate | —                              | $3\frac{1}{2}$ to $4\frac{1}{2}$ | $\frac{1}{2}$                   |
| " " vertical portion of inner bottom         | $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{16}$ to $\frac{1}{4}$ & $\frac{1}{2}$ pl.            | —                              | $3\frac{1}{2}$ to $4\frac{1}{2}$ | $\frac{1}{2}$                   |
| " " frames fore and aft of double bottom     | $4 \times 4 \times \frac{1}{16}$ to $\frac{1}{4}$ and $\frac{3}{4}$ "                                  | —                              | 4                                | $\frac{1}{2}$                   |
| Wing-passage bulkheads to edge strips        | $\frac{1}{2}$ to $\frac{1}{4}$ plate   | $3\frac{1}{2}$                 | 5                                | $\frac{1}{2}$                   |
| " " butt straps†                             | $\frac{1}{2}$ to $\frac{1}{4}$ "   | 6                              | $3\frac{1}{2}$ to 4              | $\frac{1}{2}$                   |
| " " stiffeners                               | $\frac{1}{2}$ to $\frac{1}{4}$ "   | $4\frac{1}{2}$                 | 8                                | $\frac{1}{2}$                   |
| Lower-deck stringer plate to beams           | $\frac{1}{2}$ to $\frac{1}{4}$ "   | $11\frac{1}{2}$                | $3\frac{1}{2}$ to 4              | $\frac{1}{2}$                   |
| " " butt straps                              | $\frac{1}{2}$ to $\frac{1}{4}$ "   | $8\frac{1}{2}$                 | 8                                | $\frac{1}{2}$                   |
| " " intercostal plates between frames        | $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{16}$ to $\frac{1}{4}$ & $\frac{3}{4}$ pl.            | —                              | 6                                | $\frac{1}{2}$                   |
| Main-deck beams                              | $\frac{1}{2}$ plate to angle iron  | 36                             | $3\frac{1}{2}$ to 4              | $\frac{1}{2}$                   |
| Main-deck stringer to gutter angle-irons     | " "  | $12\frac{1}{2}$                | 4                                | $\frac{1}{2}$                   |
| " " beams                                    | " "  | $4\frac{1}{2}$                 | 5                                | $\frac{1}{2}$                   |
| " "  | " "  | —                              | $3\frac{1}{2}$                   | $\frac{1}{2}$                   |
| " "  | " "  | 26                             | 7                                | $\frac{1}{2}$                   |

\* Double butt-straps, double-chain riveted. † Single-chain riveted.

TABLE OF THE SIZES AND PROPORTIONS OF RIVETS AS EMPLOYED IN H.M.S. 'HERCULES' (continued).

| Description of Work                       | Thickness of Iron<br>(in ins.) | Breadth<br>of Lap<br>(in ins.) | Width of<br>Rivets<br>(in ins.) | Diam. of<br>Rivets<br>(in ins.) |
|---|--------------------------------|--------------------------------|---------------------------------|---------------------------------|
| Main-deck stringer to butt straps         |                                | 12½ and 13                     | 4                               | 8                               |
| Plating on main deck (½ inch) to beams    |                                | —                              | 7½                              | 7½                              |
| edge strips                               |                                | 4½                             | 4½                              | 4½                              |
| butt straps*                              |                                | 8½                             | 4                               | 4                               |
| "   |                                | —                              | 5½                              | 5½                              |
| (¾ inch) to beams                         |                                | 4                              | 4                               | 4                               |
| edge strips                               |                                | 7 and 4                        | 8½                              | 8½                              |
| butt straps†                              |                                | —                              | —                               | —                               |
| Upper-deck stringer to gutter angle irons | ½-in. plate to ½ angle iron    | —                              | —                               | —                               |
| beams                                     |                                | —                              | —                               | —                               |
| butt straps†                              |                                | 86                             | 4                               | 4                               |
| steel plating (½ in.) to beams            |                                | 12½                            | 7½                              | 7½                              |
| edge strips                               |                                | —                              | 4½                              | 4½                              |
| butt straps‡                              |                                | 8½                             | 7½                              | 7½                              |
| "   |                                | —                              | —                               | —                               |
| (¾ in.) to beams                          |                                | 4                              | 7½                              | 7½                              |
| edge strips                               |                                | —                              | —                               | —                               |
| butt straps‡                              |                                | 3½                             | 5½                              | 5½                              |
| (½ in.) to beams                          |                                | —                              | —                               | —                               |
| edge strips                               |                                | 4½                             | 4½                              | 4½                              |
| butt straps‡                              |                                | —                              | —                               | —                               |
| Magazine bulkheads to stiffeners          | 8 × 3 × ½ to 1½ plate          | —                              | 5 to 6                          | 5 to 6                          |
| edge strips                               |                                | —                              | —                               | —                               |
| butt straps                               |                                | —                              | —                               | —                               |
| Plating on platforms to beams             |                                | —                              | —                               | —                               |
| edge strips                               |                                | —                              | —                               | —                               |
| butt straps*                              |                                | 4                              | 8½                              | 8½                              |
| "   |                                | 7                              | 8½                              | 8½                              |

\* Double-riveted. † Double- and single-riveted. ‡ Treble-chain riveted. § Double-chain riveted. || Single-riveted.

TABLE OF THE SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'HERCULES' (concluded).

| Description of Work                       | Thickness of Iron<br>(in Ins.)  | Length<br>of Lap<br>(in Ins.)    | Pitch of<br>Rivets<br>(in Ins.) | Diam. of<br>Rivets<br>(in Ins.) |
|---|---|----------------------------------|---------------------------------|---------------------------------|
| Short passage bulkheads to stiffeners     | $3 \times 3\frac{1}{2} \times \frac{1}{8}$ to $\frac{1}{4}$ plate                               | $8\frac{1}{2}$                   | 6                               | $\frac{1}{2}$                   |
| " " edge strips                           |   | $8\frac{1}{2}$                   | 4                               | $\frac{1}{2}$                   |
| " " butt straps                           |   |                                  | 4                               | $\frac{1}{2}$                   |
| Bidge-keel angle-irons to bottom plating† | $5 \times 4 \times \frac{1}{8}$ to $\frac{1}{4} \times \frac{1}{4}$ plates                      |                                  | 5                               | $\frac{1}{2}$                   |
| Angle iron on outer edge to shelf plate   | $5 \times 5 \times \frac{1}{8}$ to $\frac{1}{4}$ plate  |                                  | $5\frac{1}{2}$                  | $\frac{1}{2}$                   |
| " " bottom plating                        | $\frac{1}{4}$ "   |                                  | $5\frac{1}{2}$                  | $\frac{1}{2}$                   |
| " " inner edge to shelf plate             | " "   |                                  | $5\frac{1}{2}$                  | $\frac{1}{2}$                   |
| " " skin plating                          | " (two thicknesses)   |                                  | $5\frac{1}{2}$                  | $\frac{1}{2}$                   |
| Covering plate to shelf                   | $8\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{4}$ to two thicknesses of $\frac{1}{4}$ plate | 17                               | 6                               | $\frac{1}{2}$                   |
| Plating behind armour to frames           |   |                                  | 6 to 7                          | $\frac{1}{2}$                   |
| " " edge strips                           |   | $6\frac{1}{2}$                   | 5 to 6                          | $\frac{1}{2}$                   |
| " " butt straps†                          |   | $16\frac{1}{2}$                  | 5                               | $\frac{1}{2}$                   |
| " " the two thicknesses to each other     |   |                                  | 4 to $5\frac{1}{2}$             | $\frac{1}{2}$                   |
| " " to longitudinal girders               | $12 \times 8\frac{1}{2} \times \frac{1}{4}$ to two thicknesses of $\frac{1}{4}$ plates          |                                  | 6                               | $\frac{1}{2}$                   |
| " " Plating above armour to frames        | $7 \times 3\frac{1}{2} \times \frac{1}{8}$ or $\frac{1}{4}$ to $\frac{1}{2}$ plate              |                                  | $5\frac{1}{2}$                  | $\frac{1}{2}$                   |
| Before battery {                          | $4 \times 3\frac{1}{2} \times \frac{1}{8}$  |                                  | 5                               | $\frac{1}{2}$                   |
| " " edge strips                           |   | 6                                | 5                               | $\frac{1}{2}$                   |
| " " butt straps§                          |   | 9                                | 5                               | $\frac{1}{2}$                   |
| " " armour plates                         | $\frac{1}{2}$ plate to armour   | $7\frac{1}{2}$ or $5\frac{1}{2}$ | 4                               | $\frac{1}{2}$                   |
| Platform beams                            | $\frac{1}{2}$ plate to $\frac{1}{8}$ or $\frac{1}{4}$ angle iron                                |                                  | 6                               | $\frac{1}{2}$ and $\frac{1}{4}$ |
| Lower-deck beams                          | $\frac{1}{2}$ plate to $\frac{1}{4}$ angle iron   |                                  | 6                               | $\frac{1}{2}$ and $\frac{1}{4}$ |

\* Single-riveted. † Tap rivets clenched on the inside. ‡ Table-riveted for both thicknesses. § Double-riveted.

|| Double-tap riveted at the edges and treble at the butts.

TABLE OF LOGARITHMIC SINES, TANGENTS, SECANTS, &amp;c.

| Deg. | Sine    | Cosecant | Tangent | Cotangent | Secant  | Cosine  | Deg. |
|------|---------|----------|---------|-----------|---------|---------|------|
| 0    | 000000  | Infinite | 000000  | Infinite  | 1000000 | 1000000 | 90   |
| 1    | 743982  | 1236018  | 743982  | 1236018   | 1000000 | 999999  | 89   |
| 2    | 794084  | 1255916  | 794084  | 1255914   | 1000000 | 999998  | 88   |
| 3    | 844186  | 1185307  | 844186  | 1185304   | 1000000 | 999996  | 87   |
| 4    | 894288  | 1175816  | 894288  | 1175816   | 1000000 | 999995  | 86   |
| 5    | 944390  | 1166325  | 944390  | 1166322   | 1000000 | 999994  | 85   |
| 6    | 994492  | 1156834  | 994492  | 1156831   | 1000000 | 999993  | 84   |
| 7    | 1045000 | 1147343  | 1045000 | 1147340   | 1000000 | 999992  | 83   |
| 8    | 1095008 | 1137852  | 1095008 | 1137849   | 1000000 | 999991  | 82   |
| 9    | 1145016 | 1128361  | 1145016 | 1128358   | 1000000 | 999990  | 81   |
| 10   | 1195024 | 1118870  | 1195024 | 1118867   | 1000000 | 999989  | 80   |
| 11   | 1245032 | 1109379  | 1245032 | 1109376   | 1000000 | 999988  | 79   |
| 12   | 1295040 | 1100000  | 1295040 | 1100000   | 1000000 | 999987  | 78   |
| 13   | 1345048 | 1090621  | 1345048 | 1090618   | 1000000 | 999986  | 77   |
| 14   | 1395056 | 1081242  | 1395056 | 1081239   | 1000000 | 999985  | 76   |
| 15   | 1445064 | 1071863  | 1445064 | 1071860   | 1000000 | 999984  | 75   |
| 16   | 1495072 | 1062484  | 1495072 | 1062481   | 1000000 | 999983  | 74   |
| 17   | 1545080 | 1053105  | 1545080 | 1053102   | 1000000 | 999982  | 73   |
| 18   | 1595088 | 1043726  | 1595088 | 1043723   | 1000000 | 999981  | 72   |
| 19   | 1645096 | 1034347  | 1645096 | 1034344   | 1000000 | 999980  | 71   |
| 20   | 1695104 | 1024968  | 1695104 | 1024965   | 1000000 | 999979  | 70   |
| 21   | 1745112 | 1015589  | 1745112 | 1015586   | 1000000 | 999978  | 69   |
| 22   | 1795120 | 1006210  | 1795120 | 1006207   | 1000000 | 999977  | 68   |
| 23   | 1845128 | 996831   | 1845128 | 996828    | 1000000 | 999976  | 67   |
| 24   | 1895136 | 987452   | 1895136 | 987449    | 1000000 | 999975  | 66   |
| 25   | 1945144 | 978073   | 1945144 | 978070    | 1000000 | 999974  | 65   |
| 26   | 1995152 | 968694   | 1995152 | 968691    | 1000000 | 999973  | 64   |
| 27   | 2045160 | 959315   | 2045160 | 959312    | 1000000 | 999972  | 63   |
| 28   | 2095168 | 949936   | 2095168 | 949933    | 1000000 | 999971  | 62   |
| 29   | 2145176 | 940557   | 2145176 | 940554    | 1000000 | 999970  | 61   |
| 30   | 2195184 | 931178   | 2195184 | 931175    | 1000000 | 999969  | 60   |
| 31   | 2245192 | 921799   | 2245192 | 921796    | 1000000 | 999968  | 59   |
| 32   | 2295200 | 912420   | 2295200 | 912417    | 1000000 | 999967  | 58   |
| 33   | 2345208 | 903041   | 2345208 | 903038    | 1000000 | 999966  | 57   |
| 34   | 2395216 | 893662   | 2395216 | 893659    | 1000000 | 999965  | 56   |
| 35   | 2445224 | 884283   | 2445224 | 884280    | 1000000 | 999964  | 55   |
| 36   | 2495232 | 874904   | 2495232 | 874901    | 1000000 | 999963  | 54   |
| 37   | 2545240 | 865525   | 2545240 | 865522    | 1000000 | 999962  | 53   |
| 38   | 2595248 | 856146   | 2595248 | 856143    | 1000000 | 999961  | 52   |
| 39   | 2645256 | 846767   | 2645256 | 846764    | 1000000 | 999960  | 51   |
| 40   | 2695264 | 837388   | 2695264 | 837385    | 1000000 | 999959  | 50   |
| 41   | 2745272 | 828009   | 2745272 | 828006    | 1000000 | 999958  | 49   |
| 42   | 2795280 | 818630   | 2795280 | 818627    | 1000000 | 999957  | 48   |
| 43   | 2845288 | 809251   | 2845288 | 809248    | 1000000 | 999956  | 47   |
| 44   | 2895296 | 800000   | 2895296 | 800000    | 1000000 | 999955  | 46   |
| 45   | 2945304 | 790749   | 2945304 | 790746    | 1000000 | 999954  | 45   |
| 46   | 2995312 | 781498   | 2995312 | 781495    | 1000000 | 999953  | 44   |
| 47   | 3045320 | 772247   | 3045320 | 772244    | 1000000 | 999952  | 43   |
| 48   | 3095328 | 763000   | 3095328 | 763000    | 1000000 | 999951  | 42   |
| 49   | 3145336 | 753751   | 3145336 | 753751    | 1000000 | 999950  | 41   |
| 50   | 3195344 | 744500   | 3195344 | 744500    | 1000000 | 999949  | 40   |
| 51   | 3245352 | 735251   | 3245352 | 735251    | 1000000 | 999948  | 39   |
| 52   | 3295360 | 726000   | 3295360 | 726000    | 1000000 | 999947  | 38   |
| 53   | 3345368 | 716751   | 3345368 | 716751    | 1000000 | 999946  | 37   |
| 54   | 3395376 | 707500   | 3395376 | 707500    | 1000000 | 999945  | 36   |
| 55   | 3445384 | 698251   | 3445384 | 698251    | 1000000 | 999944  | 35   |
| 56   | 3495392 | 689000   | 3495392 | 689000    | 1000000 | 999943  | 34   |
| 57   | 3545400 | 679751   | 3545400 | 679751    | 1000000 | 999942  | 33   |
| 58   | 3595408 | 670500   | 3595408 | 670500    | 1000000 | 999941  | 32   |
| 59   | 3645416 | 661251   | 3645416 | 661251    | 1000000 | 999940  | 31   |
| 60   | 3695424 | 652000   | 3695424 | 652000    | 1000000 | 999939  | 30   |
| 61   | 3745432 | 642751   | 3745432 | 642751    | 1000000 | 999938  | 29   |
| 62   | 3795440 | 633500   | 3795440 | 633500    | 1000000 | 999937  | 28   |
| 63   | 3845448 | 624251   | 3845448 | 624251    | 1000000 | 999936  | 27   |
| 64   | 3895456 | 615000   | 3895456 | 615000    | 1000000 | 999935  | 26   |
| 65   | 3945464 | 605751   | 3945464 | 605751    | 1000000 | 999934  | 25   |
| 66   | 3995472 | 596500   | 3995472 | 596500    | 1000000 | 999933  | 24   |
| 67   | 4045480 | 587251   | 4045480 | 587251    | 1000000 | 999932  | 23   |
| 68   | 4095488 | 578000   | 4095488 | 578000    | 1000000 | 999931  | 22   |
| 69   | 4145496 | 568751   | 4145496 | 568751    | 1000000 | 999930  | 21   |
| 70   | 4195504 | 559500   | 4195504 | 559500    | 1000000 | 999929  | 20   |
| 71   | 4245512 | 550251   | 4245512 | 550251    | 1000000 | 999928  | 19   |
| 72   | 4295520 | 541000   | 4295520 | 541000    | 1000000 | 999927  | 18   |
| 73   | 4345528 | 531751   | 4345528 | 531751    | 1000000 | 999926  | 17   |
| 74   | 4395536 | 522500   | 4395536 | 522500    | 1000000 | 999925  | 16   |
| 75   | 4445544 | 513251   | 4445544 | 513251    | 1000000 | 999924  | 15   |
| 76   | 4495552 | 504000   | 4495552 | 504000    | 1000000 | 999923  | 14   |
| 77   | 4545560 | 494751   | 4545560 | 494751    | 1000000 | 999922  | 13   |
| 78   | 4595568 | 485500   | 4595568 | 485500    | 1000000 | 999921  | 12   |
| 79   | 4645576 | 476251   | 4645576 | 476251    | 1000000 | 999920  | 11   |
| 80   | 4695584 | 467000   | 4695584 | 467000    | 1000000 | 999919  | 10   |
| 81   | 4745592 | 457751   | 4745592 | 457751    | 1000000 | 999918  | 9    |
| 82   | 4795600 | 448500   | 4795600 | 448500    | 1000000 | 999917  | 8    |
| 83   | 4845608 | 439251   | 4845608 | 439251    | 1000000 | 999916  | 7    |
| 84   | 4895616 | 430000   | 4895616 | 430000    | 1000000 | 999915  | 6    |
| 85   | 4945624 | 420751   | 4945624 | 420751    | 1000000 | 999914  | 5    |
| 86   | 4995632 | 411500   | 4995632 | 411500    | 1000000 | 999913  | 4    |
| 87   | 5045640 | 402251   | 5045640 | 402251    | 1000000 | 999912  | 3    |
| 88   | 5095648 | 393000   | 5095648 | 393000    | 1000000 | 999911  | 2    |
| 89   | 5145656 | 383751   | 5145656 | 383751    | 1000000 | 999910  | 1    |
| 90   | 5195664 | 374500   | 5195664 | 374500    | 1000000 | 999909  | 0    |

| Day | Sine    | Cosine   | Tangent   | Cotangent | Secant   | Cosecant | Day |
|-----|---------|----------|-----------|-----------|----------|----------|-----|
| 10  | 9-27073 | 10-72927 | 9-27442   | 10-72158  | 10-00769 | 9-99231  |     |
| 11  | 9-27080 | 10-71940 | 9-28465   | 10-71135  | 10-00805 | 9-99195  | 79  |
|     | 9-27074 | 10-70976 | 9-29466   | 10-70134  | 10-00843 | 9-99157  |     |
|     | 9-27066 | 10-70034 | 9-30446   | 10-69184  | 10-00881 | 9-99119  |     |
|     | 9-30887 | 10-69118 | 9-31408   | 10-68194  | 10-00920 | 9-99080  |     |
| 12  | 9-31786 | 10-68212 | 9-32747   | 10-67253  | 10-00960 | 9-99040  | 78  |
|     | 9-32670 | 10-67330 | 9-33670   | 10-66330  | 10-01000 | 9-99000  |     |
|     | 9-33534 | 10-66466 | 9-34574   | 10-65424  | 10-01042 | 9-98958  |     |
|     | 9-34380 | 10-65620 | 9-35464   | 10-64536  | 10-01084 | 9-98916  |     |
| 13  | 9-35209 | 10-64791 | 9-36336   | 10-63664  | 10-01128 | 9-98872  | 77  |
|     | 9-36022 | 10-63978 | 9-37193   | 10-62807  | 10-01172 | 9-98828  |     |
|     | 9-36819 | 10-63181 | 9-38033   | 10-61968  | 10-01217 | 9-98783  |     |
|     | 9-37600 | 10-62400 | 9-38863   | 10-61137  | 10-01263 | 9-98737  |     |
| 14  | 9-38368 | 10-61632 | 9-39677   | 10-60323  | 10-01310 | 9-98690  | 76  |
|     | 9-39121 | 10-60879 | 9-40478   | 10-59522  | 10-01357 | 9-98643  |     |
|     | 9-39860 | 10-60140 | 9-41266   | 10-58734  | 10-01405 | 9-98594  |     |
|     | 9-40586 | 10-59414 | 9-42041   | 10-57959  | 10-01455 | 9-98545  |     |
| 15  | 9-41300 | 10-58700 | 9-42803   | 10-57198  | 10-01506 | 9-98494  | 75  |
|     | 9-42001 | 10-57999 | 9-43553   | 10-56442  | 10-01557 | 9-98443  |     |
|     | 9-42690 | 10-57310 | 9-44299   | 10-55701  | 10-01608 | 9-98391  |     |
|     | 9-43367 | 10-56633 | 9-45029   | 10-54971  | 10-01662 | 9-98338  |     |
| 16  | 9-44034 | 10-55966 | 9-45750   | 10-54250  | 10-01716 | 9-98284  | 74  |
|     | 9-44689 | 10-55311 | 9-46460   | 10-53540  | 10-01771 | 9-98229  |     |
|     | 9-45334 | 10-54666 | 9-47160   | 10-52840  | 10-01826 | 9-98174  |     |
|     | 9-45969 | 10-54031 | 9-47852   | 10-52148  | 10-01883 | 9-98117  |     |
| 17  | 9-46594 | 10-53406 | 9-48534   | 10-51466  | 10-01940 | 9-98060  | 73  |
|     | 9-47209 | 10-52791 | 9-49207   | 10-50793  | 10-01999 | 9-98001  |     |
|     | 9-47814 | 10-52186 | 9-49872   | 10-50128  | 10-02058 | 9-97942  |     |
|     | 9-48411 | 10-51589 | 9-50529   | 10-49471  | 10-02118 | 9-97883  |     |
| 18  | 9-48998 | 10-51002 | 9-51174   | 10-48822  | 10-02178 | 9-97821  | 72  |
|     | 9-49577 | 10-50423 | 9-51812   | 10-48181  | 10-02241 | 9-97759  |     |
|     | 9-50148 | 10-49852 | 9-52453   | 10-47548  | 10-02304 | 9-97696  |     |
|     | 9-50710 | 10-49280 | 9-53078   | 10-46922  | 10-02368 | 9-97633  |     |
| 19  | 9-51264 | 10-48736 | 9-53697   | 10-46303  | 10-02433 | 9-97567  | 71  |
|     | 9-51811 | 10-48189 | 9-54309   | 10-45691  | 10-02499 | 9-97501  |     |
|     | 9-52350 | 10-47650 | 9-54915   | 10-45085  | 10-02565 | 9-97435  |     |
|     | 9-52881 | 10-47119 | 9-55514   | 10-44486  | 10-02633 | 9-97367  |     |
| 20  | 9-53405 | 10-46595 | 9-56107   | 10-43893  | 10-02701 | 9-97299  | 70  |
|     | 9-53922 | 10-46078 | 9-56693   | 10-43307  | 10-02771 | 9-97229  |     |
|     | 9-54433 | 10-45567 | 9-57274   | 10-42726  | 10-02841 | 9-97159  |     |
|     | 9-54936 | 10-45064 | 9-57849   | 10-42151  | 10-02913 | 9-97087  |     |
| 21  | 9-55433 | 10-44567 | 9-58418   | 10-41582  | 10-02985 | 9-97015  | 69  |
|     | 9-55923 | 10-44077 | 9-58981   | 10-41019  | 10-03058 | 9-96942  |     |
|     | 9-56408 | 10-43592 | 9-59540   | 10-40463  | 10-03132 | 9-96868  |     |
|     | 9-56886 | 10-43114 | 9-60093   | 10-39907  | 10-03207 | 9-96793  |     |
| 22  | 9-57358 | 10-42642 | 9-60641   | 10-39359  | 10-03283 | 9-96717  | 68  |
| Day | Cosine  | Secant   | Cotangent | Tangent   | Cosecant | Sine     | Day |

| Deg. | Sine    | Cosecant | Tangent   | Cotangent | Secant   | Cosine  | Deg. |
|------|---------|----------|-----------|-----------|----------|---------|------|
| 22   | 9.57824 | 10.42176 | 9.61184   | 10.38816  | 10.03360 | 9.96640 | 34   |
|      | 9.58284 | 10.41716 | 9.61722   | 10.38278  | 10.03488 | 9.96562 | 34   |
|      | 9.58739 | 10.41261 | 9.62256   | 10.37744  | 10.03517 | 9.96483 | 34   |
| 23   | 9.59188 | 10.40812 | 9.62785   | 10.37215  | 10.03597 | 9.96403 | 67   |
|      | 9.59632 | 10.40368 | 9.63310   | 10.36690  | 10.03678 | 9.96322 | 34   |
|      | 9.60070 | 10.39930 | 9.63830   | 10.36170  | 10.03760 | 9.96240 | 34   |
|      | 9.60503 | 10.39497 | 9.64346   | 10.35654  | 10.03843 | 9.96157 | 34   |
| 24   | 9.60931 | 10.39069 | 9.64858   | 10.35142  | 10.03927 | 9.96073 | 66   |
|      | 9.61354 | 10.38646 | 9.65366   | 10.34634  | 10.04012 | 9.95988 | 34   |
|      | 9.61773 | 10.38227 | 9.65870   | 10.34130  | 10.04098 | 9.95902 | 34   |
|      | 9.62186 | 10.37814 | 9.66371   | 10.33629  | 10.04185 | 9.95815 | 34   |
| 25   | 9.62595 | 10.37405 | 9.66867   | 10.33133  | 10.04272 | 9.95728 | 65   |
|      | 9.62999 | 10.37001 | 9.67360   | 10.32640  | 10.04361 | 9.95639 | 34   |
|      | 9.63398 | 10.36602 | 9.67850   | 10.32150  | 10.04451 | 9.95549 | 34   |
|      | 9.63794 | 10.36206 | 9.68336   | 10.31664  | 10.04542 | 9.95458 | 34   |
| 26   | 9.64184 | 10.35816 | 9.68818   | 10.31182  | 10.04634 | 9.95366 | 64   |
|      | 9.64571 | 10.35429 | 9.69298   | 10.30703  | 10.04727 | 9.95273 | 34   |
|      | 9.64953 | 10.35047 | 9.69774   | 10.30226  | 10.04821 | 9.95179 | 34   |
|      | 9.65331 | 10.34669 | 9.70247   | 10.29753  | 10.04916 | 9.95084 | 34   |
| 27   | 9.65705 | 10.34295 | 9.70717   | 10.29283  | 10.05012 | 9.94988 | 63   |
|      | 9.66075 | 10.33925 | 9.71184   | 10.28816  | 10.05109 | 9.94891 | 34   |
|      | 9.66441 | 10.33559 | 9.71648   | 10.28352  | 10.05207 | 9.94793 | 34   |
|      | 9.66808 | 10.33197 | 9.72109   | 10.27891  | 10.05306 | 9.94694 | 34   |
| 28   | 9.67161 | 10.32839 | 9.72567   | 10.27433  | 10.05407 | 9.94593 | 62   |
|      | 9.67515 | 10.32485 | 9.73023   | 10.26977  | 10.05508 | 9.94492 | 34   |
|      | 9.67866 | 10.32134 | 9.73476   | 10.26524  | 10.05610 | 9.94390 | 34   |
|      | 9.68213 | 10.31787 | 9.73927   | 10.26073  | 10.05714 | 9.94286 | 34   |
| 29   | 9.68557 | 10.31443 | 9.74375   | 10.25625  | 10.05818 | 9.94182 | 61   |
|      | 9.68897 | 10.31103 | 9.74821   | 10.25179  | 10.05924 | 9.94076 | 34   |
|      | 9.69234 | 10.30766 | 9.75264   | 10.24736  | 10.06030 | 9.93970 | 34   |
|      | 9.69567 | 10.30433 | 9.75705   | 10.24295  | 10.06138 | 9.93862 | 34   |
| 30   | 9.69897 | 10.30103 | 9.76144   | 10.23856  | 10.06247 | 9.93753 | 60   |
|      | 9.70224 | 10.29776 | 9.76580   | 10.23420  | 10.06357 | 9.93643 | 34   |
|      | 9.70547 | 10.29453 | 9.77015   | 10.22985  | 10.06468 | 9.93532 | 34   |
|      | 9.70867 | 10.29133 | 9.77447   | 10.22553  | 10.06580 | 9.93420 | 34   |
| 31   | 9.71184 | 10.28816 | 9.77877   | 10.22123  | 10.06693 | 9.93307 | 59   |
|      | 9.71498 | 10.28502 | 9.78306   | 10.21694  | 10.06808 | 9.93192 | 34   |
|      | 9.71809 | 10.28191 | 9.78732   | 10.21268  | 10.06923 | 9.93077 | 34   |
|      | 9.72116 | 10.27884 | 9.79156   | 10.20844  | 10.07040 | 9.92960 | 34   |
| 32   | 9.72421 | 10.27579 | 9.79579   | 10.20421  | 10.07158 | 9.92842 | 58   |
|      | 9.72723 | 10.27277 | 9.80000   | 10.20000  | 10.07277 | 9.92723 | 34   |
|      | 9.73022 | 10.26978 | 9.80419   | 10.19581  | 10.07397 | 9.92603 | 34   |
|      | 9.73318 | 10.26682 | 9.80836   | 10.19164  | 10.07518 | 9.92482 | 34   |
| 33   | 9.73611 | 10.26389 | 9.81252   | 10.18748  | 10.07641 | 9.92359 | 57   |
|      | 9.73901 | 10.26099 | 9.81666   | 10.18334  | 10.07765 | 9.92235 | 34   |
|      | 9.74189 | 10.25811 | 9.82078   | 10.17922  | 10.07889 | 9.92111 | 56   |
| Deg. | Cosine  | Secant   | Cotangent | Tangent   | Cosecant | Sine    | Deg. |



| Deg. | Sine    | Coscant  | Tangent   | Cotangent | Secant   | Cosine  | Deg. |
|------|---------|----------|-----------|-----------|----------|---------|------|
| 33   | 9-74474 | 10-25526 | 9-82489   | 10-17511  | 10-08015 | 9-91985 | 1    |
| 34   | 9-74756 | 10-25244 | 9-82809   | 10-17101  | 10-08148 | 9-91857 | 34   |
|      | 9-75038 | 10-24964 | 9-83307   | 10-16693  | 10-08271 | 9-91729 |      |
|      | 9-75318 | 10-24687 | 9-83713   | 10-16287  | 10-08401 | 9-91599 |      |
|      | 9-75587 | 10-24413 | 9-84119   | 10-15881  | 10-08531 | 9-91469 |      |
| 35   | 9-75859 | 10-24141 | 9-84523   | 10-15477  | 10-08664 | 9-91336 | 55   |
|      | 9-76129 | 10-23871 | 9-84923   | 10-15075  | 10-08797 | 9-91203 |      |
|      | 9-76395 | 10-23603 | 9-85327   | 10-14673  | 10-08931 | 9-91069 |      |
|      | 9-76660 | 10-23340 | 9-85727   | 10-14273  | 10-09067 | 9-90933 |      |
| 36   | 9-76922 | 10-23078 | 9-86126   | 10-13874  | 10-09204 | 9-90796 | 54   |
|      | 9-77182 | 10-22819 | 9-86524   | 10-13476  | 10-09343 | 9-90657 |      |
|      | 9-77439 | 10-22561 | 9-86921   | 10-13079  | 10-09482 | 9-90518 |      |
|      | 9-77694 | 10-22306 | 9-87317   | 10-12683  | 10-09623 | 9-90377 |      |
| 37   | 9-77946 | 10-22054 | 9-87711   | 10-12289  | 10-09765 | 9-90235 | 53   |
|      | 9-78197 | 10-21803 | 9-88103   | 10-11895  | 10-09909 | 9-90091 |      |
|      | 9-78445 | 10-21555 | 9-88498   | 10-11502  | 10-10053 | 9-89947 |      |
|      | 9-78691 | 10-21309 | 9-88890   | 10-11110  | 10-10199 | 9-89801 |      |
| 38   | 9-78934 | 10-21066 | 9-89281   | 10-10719  | 10-10347 | 9-89655 | 52   |
|      | 9-79176 | 10-20824 | 9-89671   | 10-10329  | 10-10496 | 9-89508 |      |
|      | 9-79415 | 10-20585 | 9-90061   | 10-09939  | 10-10646 | 9-89354 |      |
|      | 9-79652 | 10-20348 | 9-90449   | 10-09551  | 10-10797 | 9-89203 |      |
| 39   | 9-79887 | 10-20113 | 9-90837   | 10-09163  | 10-10950 | 9-89050 | 51   |
|      | 9-80120 | 10-19880 | 9-91224   | 10-08776  | 10-11104 | 9-88896 |      |
|      | 9-80351 | 10-19649 | 9-91610   | 10-08390  | 10-11259 | 9-88741 |      |
|      | 9-80580 | 10-19420 | 9-91996   | 10-08003  | 10-11416 | 9-88584 |      |
| 40   | 9-80807 | 10-19193 | 9-92381   | 10-07612  | 10-11575 | 9-88425 | 50   |
|      | 9-81032 | 10-18968 | 9-92766   | 10-07224  | 10-11734 | 9-88266 |      |
|      | 9-81254 | 10-18746 | 9-93150   | 10-06830  | 10-11895 | 9-88105 |      |
|      | 9-81475 | 10-18525 | 9-93533   | 10-06437  | 10-12058 | 9-87942 |      |
| 41   | 9-81694 | 10-18306 | 9-93916   | 10-06044  | 10-12222 | 9-87778 | 49   |
|      | 9-81911 | 10-18089 | 9-94298   | 10-05650  | 10-12387 | 9-87613 |      |
|      | 9-82126 | 10-17874 | 9-94681   | 10-05259  | 10-12554 | 9-87446 |      |
|      | 9-82340 | 10-17660 | 9-95062   | 10-04868  | 10-12723 | 9-87277 |      |
| 42   | 9-82551 | 10-17449 | 9-95444   | 10-04476  | 10-12893 | 9-87107 | 48   |
|      | 9-82761 | 10-17239 | 9-95825   | 10-04085  | 10-13064 | 9-86936 |      |
|      | 9-82968 | 10-17032 | 9-96205   | 10-03695  | 10-13237 | 9-86763 |      |
|      | 9-83174 | 10-16826 | 9-96586   | 10-03304  | 10-13411 | 9-86589 |      |
| 43   | 9-83378 | 10-16622 | 9-96966   | 10-02913  | 10-13587 | 9-86413 | 47   |
|      | 9-83581 | 10-16419 | 9-97345   | 10-02523  | 10-13765 | 9-86235 |      |
|      | 9-83781 | 10-16219 | 9-97723   | 10-02133  | 10-13944 | 9-86056 |      |
|      | 9-83980 | 10-16020 | 9-98104   | 10-01743  | 10-14124 | 9-85876 |      |
| 44   | 9-84177 | 10-15823 | 9-98484   | 10-01353  | 10-14307 | 9-85693 | 46   |
|      | 9-84373 | 10-15628 | 9-98863   | 10-00963  | 10-14490 | 9-85510 |      |
|      | 9-84566 | 10-15434 | 9-99242   | 10-00573  | 10-14676 | 9-85324 |      |
|      | 9-84758 | 10-15242 | 9-99621   | 10-00183  | 10-14863 | 9-85137 |      |
| 45   | 9-84949 | 10-15052 | 10-00000  | 10-00000  | 10-15052 | 9-84949 | 45   |
| Page | Cosine  | Secant   | Cotangent | Tangent   | Coscant  | Sine    | Page |

TABLE OF NATURAL SINE, TANGENT, SECANT, &amp;c.

| Deg. | Sine   | Cosine   | Tangent   | Cotangent | Secant  | Cosec   | Log. |
|------|--------|----------|-----------|-----------|---------|---------|------|
| 0    | 00000  | Infinite | 00000     | Infinite  | 1.00000 | 1.00000 | 90   |
| 1    | 004363 | 229 1839 | 004363    | 229 1817  | 1.00010 | 999991  |      |
|      | 008727 | 114 5930 | 008727    | 114 5857  | 1.00035 | 999642  |      |
|      | 013090 | 76 39655 | 013091    | 76 39001  | 1.00066 | 999144  |      |
| 1    | 017452 | 57 29869 | 017453    | 57 29296  | 1.00102 | 998418  | 89   |
|      | 021815 | 43 84026 | 021820    | 43 82935  | 1.00142 | 997462  |      |
|      | 026177 | 33 20155 | 026186    | 33 18846  | 1.00184 | 996287  |      |
|      | 030539 | 22 74554 | 030553    | 22 73026  | 1.00229 | 994834  |      |
| 2    | 034900 | 18 65371 | 034921    | 18 63625  | 1.00276 | 993191  | 88   |
|      | 039260 | 13 47134 | 039290    | 13 45170  | 1.00325 | 991279  |      |
|      | 043619 | 9 29239  | 043661    | 9 27037   | 1.00375 | 989048  |      |
|      | 047978 | 6 84283  | 048033    | 6 81883   | 1.00427 | 986848  |      |
| 3    | 052336 | 4 10732  | 052408    | 4 08114   | 1.00481 | 984330  | 87   |
|      | 056693 | 2 63897  | 056784    | 2 61056   | 1.00536 | 981392  |      |
|      | 061049 | 1 38041  | 061163    | 1 34986   | 1.00592 | 978135  |      |
|      | 065403 | 0 28979  | 065544    | 0 25705   | 1.00650 | 973859  |      |
| 4    | 069757 | 0 33559  | 069927    | 0 30067   | 1.00709 | 968564  | 86   |
|      | 074109 | 0 49273  | 074318    | 0 45663   | 1.00770 | 962260  |      |
|      | 078459 | 12 74554 | 078702    | 12 70621  | 1.00832 | 954917  |      |
|      | 082808 | 12 07610 | 083094    | 12 03462  | 1.00895 | 946566  |      |
| 5    | 087156 | 11 47371 | 087489    | 11 43005  | 1.00960 | 936195  | 85   |
|      | 091502 | 10 92877 | 091887    | 10 88292  | 1.01026 | 924805  |      |
|      | 095846 | 10 43343 | 096289    | 10 38540  | 1.01093 | 912396  |      |
|      | 100188 | 9 981229 | 100695    | 9 93100   | 1.01161 | 899069  |      |
| 6    | 104529 | 9 566772 | 105104    | 9 514365  | 1.01230 | 884822  | 84   |
|      | 108867 | 9 183331 | 109518    | 9 130945  | 1.01300 | 869656  |      |
|      | 113203 | 8 833672 | 113936    | 8 776887  | 1.01371 | 853572  |      |
|      | 117537 | 8 507930 | 118358    | 8 448957  | 1.01443 | 836569  |      |
| 7    | 121869 | 8 203300 | 122785    | 8 144346  | 1.01516 | 818546  | 83   |
|      | 126199 | 7 928995 | 127216    | 7 860642  | 1.01590 | 799005  |      |
|      | 130526 | 7 661298 | 131653    | 7 595754  | 1.01665 | 778145  |      |
|      | 134851 | 7 405396 | 136094    | 7 347861  | 1.01741 | 755866  |      |
| 8    | 139173 | 7 155297 | 140541    | 7 115370  | 1.01818 | 732268  | 82   |
|      | 143493 | 6 916899 | 144993    | 6 886800  | 1.01896 | 697651  |      |
|      | 147809 | 6 684465 | 149451    | 6 661156  | 1.01975 | 662016  |      |
|      | 152123 | 6 457361 | 153915    | 6 437104  | 1.02055 | 625362  |      |
| 9    | 156435 | 6 235245 | 158384    | 6 313752  | 1.02136 | 587688  | 81   |
|      | 160743 | 6 017112 | 162860    | 6 140220  | 1.02218 | 548996  |      |
|      | 165048 | 5 802858 | 167343    | 5 975764  | 1.02301 | 509296  |      |
|      | 169350 | 5 592484 | 171831    | 5 819657  | 1.02385 | 468556  |      |
| 10   | 173648 | 5 385771 | 176327    | 5 671282  | 1.02470 | 426808  | 80   |
|      | 177944 | 5 182760 | 180830    | 5 530072  | 1.02556 | 384041  |      |
|      | 182236 | 5 487404 | 185339    | 5 395517  | 1.02643 | 340255  | 79   |
| Log. | Cosine | Secant   | Cotangent | Tangent   | Cosine  | Sine    | Log. |

| Deg.             | Sine    | Cosecant | Tangent   | Cotangent | Secant   | Cosine  | Deg.            |
|------------------|---------|----------|-----------|-----------|----------|---------|-----------------|
| 10 $\frac{1}{2}$ | ·186524 | 5·361239 | ·189856   | 5·267152  | 1·017863 | ·982450 | 1 $\frac{1}{2}$ |
| 11               | ·190809 | 5·240843 | ·194380   | 5·144554  | 1·018717 | ·981627 | 79              |
| $\frac{1}{4}$    | ·195090 | 5·125831 | ·198912   | 5·027340  | 1·019591 | ·980785 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·199368 | 5·015852 | ·203452   | 4·915157  | 1·020487 | ·979925 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·203642 | 4·910584 | ·208000   | 4·807685  | 1·021403 | ·979046 | $\frac{1}{4}$   |
| 12               | ·207912 | 4·809734 | ·212557   | 4·704630  | 1·022341 | ·978148 | 78              |
| $\frac{1}{4}$    | ·212178 | 4·713031 | ·217121   | 4·605721  | 1·023299 | ·977231 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·216440 | 4·620226 | ·221695   | 4·510709  | 1·024280 | ·976296 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·220697 | 4·531090 | ·226277   | 4·419364  | 1·025281 | ·975342 | $\frac{1}{4}$   |
| 13               | ·224951 | 4·445412 | ·230868   | 4·331476  | 1·026304 | ·974370 | 77              |
| $\frac{1}{4}$    | ·229200 | 4·362994 | ·235469   | 4·246848  | 1·027349 | ·973379 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·233445 | 4·283658 | ·240079   | 4·165300  | 1·028415 | ·972370 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·237686 | 4·207233 | ·244698   | 4·086663  | 1·029503 | ·971342 | $\frac{1}{4}$   |
| 14               | ·241922 | 4·133566 | ·249328   | 4·010781  | 1·030614 | ·970296 | 76              |
| $\frac{1}{4}$    | ·246153 | 4·062509 | ·253968   | 3·937509  | 1·031746 | ·969231 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·250380 | 3·993929 | ·258618   | 3·866713  | 1·032900 | ·968148 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·254602 | 3·927700 | ·263278   | 3·798266  | 1·034077 | ·967046 | $\frac{1}{4}$   |
| 15               | ·258819 | 3·863703 | ·267949   | 3·732051  | 1·035276 | ·965926 | 75              |
| $\frac{1}{4}$    | ·263031 | 3·801830 | ·272631   | 3·667958  | 1·036498 | ·964787 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·267238 | 3·741978 | ·277325   | 3·605884  | 1·037742 | ·963631 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·271440 | 3·684049 | ·282029   | 3·545733  | 1·039009 | ·962455 | $\frac{1}{4}$   |
| 16               | ·275637 | 3·627955 | ·286745   | 3·487414  | 1·040299 | ·961262 | 74              |
| $\frac{1}{4}$    | ·279829 | 3·573611 | ·291473   | 3·430845  | 1·041613 | ·960050 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·284015 | 3·520937 | ·296214   | 3·375943  | 1·042949 | ·958820 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·288196 | 3·469858 | ·300966   | 3·322636  | 1·044309 | ·957571 | $\frac{1}{4}$   |
| 17               | ·292372 | 3·420304 | ·305731   | 3·270853  | 1·045692 | ·956305 | 73              |
| $\frac{1}{4}$    | ·296542 | 3·372208 | ·310508   | 3·220526  | 1·047099 | ·955020 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·300706 | 3·325510 | ·315299   | 3·171595  | 1·048529 | ·953717 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·304864 | 3·280148 | ·320103   | 3·123999  | 1·049984 | ·952396 | $\frac{1}{4}$   |
| 18               | ·309017 | 3·236068 | ·324920   | 3·077684  | 1·051462 | ·951057 | 72              |
| $\frac{1}{4}$    | ·313164 | 3·193217 | ·329751   | 3·032595  | 1·052965 | ·949699 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·317305 | 3·151545 | ·334595   | 2·988685  | 1·054492 | ·948324 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·321440 | 3·111006 | ·339454   | 2·945905  | 1·056044 | ·946930 | $\frac{1}{4}$   |
| 19               | ·325568 | 3·071554 | ·344328   | 2·904211  | 1·057621 | ·945519 | 71              |
| $\frac{1}{4}$    | ·329691 | 3·033146 | ·349216   | 2·863560  | 1·059222 | ·944089 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·333807 | 2·995744 | ·354119   | 2·823913  | 1·060849 | ·942642 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·337917 | 2·959309 | ·359037   | 2·785231  | 1·062501 | ·941176 | $\frac{1}{4}$   |
| 20               | ·342020 | 2·923804 | ·363970   | 2·747477  | 1·064178 | ·939693 | 70              |
| $\frac{1}{4}$    | ·346117 | 2·889196 | ·368920   | 2·710619  | 1·065881 | ·938191 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·350207 | 2·855451 | ·373885   | 2·674622  | 1·067609 | ·936672 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·354291 | 2·822538 | ·378866   | 2·639455  | 1·069364 | ·935135 | $\frac{1}{4}$   |
| 21               | ·358368 | 2·790428 | ·383864   | 2·605089  | 1·071145 | ·933580 | 69              |
| $\frac{1}{4}$    | ·362438 | 2·759092 | ·388879   | 2·571496  | 1·072952 | ·932008 | $\frac{3}{4}$   |
| $\frac{1}{2}$    | ·366501 | 2·728504 | ·393911   | 2·538648  | 1·074786 | ·930418 | $\frac{1}{2}$   |
| $\frac{3}{4}$    | ·370557 | 2·698637 | ·398960   | 2·506520  | 1·076647 | ·928810 | $\frac{1}{4}$   |
| 22               | ·374607 | 2·669467 | ·404026   | 2·475087  | 1·078535 | ·927184 | 68              |
| Deg.             | Cosine  | Secant   | Cotangent | Tangent   | Cosecant | Sine    | Deg.            |

| Deg. | Sine    | Cosecant | Tangent   | Cotangent | Secant   | Cosine  | Deg. |
|------|---------|----------|-----------|-----------|----------|---------|------|
| 22   | ·978649 | 2·640971 | ·409111   | 2·444326  | 1·080450 | ·925541 | 67   |
|      | ·882683 | 2·613126 | ·414214   | 2·414214  | 1·082392 | ·923880 |      |
|      | ·886711 | 2·585911 | ·419335   | 2·384729  | 1·084362 | ·922201 |      |
| 23   | ·390731 | 2·559305 | ·424475   | 2·355852  | 1·086360 | ·920505 | 67   |
|      | ·394744 | 2·533288 | ·429634   | 2·327563  | 1·088387 | ·918791 |      |
|      | ·398749 | 2·507843 | ·434812   | 2·299843  | 1·090441 | ·917060 |      |
|      | ·402747 | 2·482950 | ·440011   | 2·272673  | 1·092524 | ·915312 |      |
| 24   | ·406737 | 2·458593 | ·445229   | 2·246037  | 1·094636 | ·913546 | 66   |
|      | ·410719 | 2·434756 | ·450467   | 2·219918  | 1·096777 | ·911762 |      |
|      | ·414693 | 2·411421 | ·455726   | 2·194300  | 1·098948 | ·909961 |      |
|      | ·418660 | 2·388575 | ·461006   | 2·169168  | 1·101148 | ·908148 |      |
| 25   | ·422618 | 2·366202 | ·466308   | 2·144507  | 1·103378 | ·906308 | 65   |
|      | ·426569 | 2·344288 | ·471631   | 2·120303  | 1·105638 | ·904455 |      |
|      | ·430511 | 2·322821 | ·476976   | 2·096544  | 1·107929 | ·902585 |      |
|      | ·434445 | 2·301786 | ·482343   | 2·073215  | 1·110250 | ·900698 |      |
| 26   | ·438371 | 2·281172 | ·487733   | 2·050304  | 1·112602 | ·898794 | 64   |
|      | ·442289 | 2·260967 | ·493145   | 2·027799  | 1·114985 | ·896873 |      |
|      | ·446198 | 2·241159 | ·498582   | 2·005690  | 1·117400 | ·894934 |      |
|      | ·450098 | 2·221736 | ·504042   | 1·983964  | 1·119847 | ·892979 |      |
| 27   | ·453991 | 2·202689 | ·509525   | 1·962611  | 1·122826 | ·891007 | 63   |
|      | ·457874 | 2·184007 | ·515084   | 1·941620  | 1·124838 | ·889017 |      |
|      | ·461749 | 2·165681 | ·520567   | 1·920982  | 1·127882 | ·887011 |      |
|      | ·465615 | 2·147699 | ·526126   | 1·900687  | 1·129959 | ·884988 |      |
| 28   | ·469472 | 2·130055 | ·531709   | 1·880727  | 1·132570 | ·882948 | 62   |
|      | ·473320 | 2·112737 | ·537319   | 1·861091  | 1·135215 | ·880891 |      |
|      | ·477159 | 2·095739 | ·542956   | 1·841771  | 1·137893 | ·878817 |      |
|      | ·480989 | 2·079051 | ·548619   | 1·822759  | 1·140606 | ·876727 |      |
| 29   | ·484810 | 2·062665 | ·554309   | 1·804048  | 1·143354 | ·874620 | 61   |
|      | ·488621 | 2·046575 | ·560027   | 1·785629  | 1·146137 | ·872496 |      |
|      | ·492424 | 2·030772 | ·565773   | 1·767494  | 1·148956 | ·870356 |      |
|      | ·496217 | 2·015249 | ·571547   | 1·749637  | 1·151810 | ·868199 |      |
| 30   | ·500000 | 2·000000 | ·577350   | 1·732051  | 1·154701 | ·866025 | 60   |
|      | ·503774 | 1·985017 | ·583183   | 1·714728  | 1·157628 | ·863836 |      |
|      | ·507538 | 1·970294 | ·589045   | 1·697663  | 1·160592 | ·861629 |      |
|      | ·511293 | 1·955325 | ·594938   | 1·680849  | 1·163594 | ·859406 |      |
| 31   | ·515038 | 1·941604 | ·600861   | 1·664280  | 1·166633 | ·857167 | 59   |
|      | ·518773 | 1·927624 | ·606815   | 1·647949  | 1·169711 | ·854912 |      |
|      | ·522499 | 1·913881 | ·612801   | 1·631852  | 1·172828 | ·852640 |      |
|      | ·526214 | 1·900368 | ·618819   | 1·615982  | 1·175983 | ·850352 |      |
| 32   | ·529919 | 1·887080 | ·624869   | 1·600335  | 1·179178 | ·848048 | 58   |
|      | ·533615 | 1·874012 | ·630953   | 1·584904  | 1·182414 | ·845728 |      |
|      | ·537300 | 1·861159 | ·637070   | 1·569686  | 1·185689 | ·843391 |      |
|      | ·540975 | 1·848516 | ·643222   | 1·554674  | 1·189006 | ·841039 |      |
| 33   | ·544639 | 1·836079 | ·649408   | 1·539865  | 1·192363 | ·838671 | 57   |
|      | ·548293 | 1·823842 | ·655629   | 1·525254  | 1·195763 | ·836286 |      |
|      | ·551937 | 1·811801 | ·661886   | 1·510835  | 1·199205 | ·833886 | 56   |
| Deg. | Cosine  | Secant   | Cotangent | Tangent   | Cosecant | Sine    | Deg. |

| Deg. | Sine   | Cosecant | Tangent   | Cotangent | Secant   | Cosine  | Deg. |
|------|--------|----------|-----------|-----------|----------|---------|------|
| 33   | 555570 | 1.799852 | 688179    | 1.456606  | 1.202690 | .831470 |      |
| 34   | 559198 | 1.788292 | 674509    | 1.482561  | 1.206216 | .829038 | 56   |
|      | 562805 | 1.776815 | 680676    | 1.468697  | 1.209790 | .826590 |      |
|      | 566406 | 1.765517 | 687281    | 1.455009  | 1.213406 | .824126 |      |
|      | 569997 | 1.754396 | 693725    | 1.441494  | 1.217068 | .821647 |      |
| 35   | 573576 | 1.743447 | 700208    | 1.428148  | 1.220775 | .819152 | 55   |
|      | 577145 | 1.732656 | 706730    | 1.414967  | 1.224527 | .816642 |      |
|      | 580708 | 1.722061 | 713293    | 1.401949  | 1.228327 | .814116 |      |
|      | 584250 | 1.711597 | 719897    | 1.389088  | 1.232174 | .811574 |      |
| 36   | 587785 | 1.701302 | 726545    | 1.376382  | 1.236068 | .809017 | 54   |
|      | 591310 | 1.691161 | 733230    | 1.363828  | 1.240011 | .806445 |      |
|      | 594823 | 1.681173 | 739961    | 1.351422  | 1.244008 | .803857 |      |
|      | 598325 | 1.671334 | 746735    | 1.339162  | 1.248044 | .801254 |      |
| 37   | 601815 | 1.661640 | 753554    | 1.327045  | 1.252126 | .798636 | 53   |
|      | 605294 | 1.652090 | 760418    | 1.315067  | 1.256278 | .796002 |      |
|      | 608761 | 1.642680 | 767327    | 1.303225  | 1.260472 | .793353 |      |
|      | 612217 | 1.633407 | 774283    | 1.291518  | 1.264719 | .790690 |      |
| 38   | 615662 | 1.624269 | 781286    | 1.279942  | 1.269018 | .788011 | 52   |
|      | 619094 | 1.615264 | 788336    | 1.268494  | 1.273371 | .785317 |      |
|      | 622515 | 1.606398 | 795436    | 1.257172  | 1.277779 | .782608 |      |
|      | 625924 | 1.597639 | 802583    | 1.245974  | 1.282241 | .779885 |      |
| 39   | 629320 | 1.589016 | 809784    | 1.234897  | 1.286760 | .777146 | 51   |
|      | 632705 | 1.580515 | 817034    | 1.223939  | 1.291335 | .774393 |      |
|      | 636078 | 1.572134 | 824336    | 1.213097  | 1.295967 | .771625 |      |
|      | 639439 | 1.563871 | 831691    | 1.202369  | 1.300658 | .768842 |      |
| 40   | 642788 | 1.555724 | 839100    | 1.191754  | 1.305407 | .766044 | 50   |
|      | 646124 | 1.547691 | 846563    | 1.181248  | 1.310217 | .763233 |      |
|      | 649448 | 1.539769 | 854081    | 1.170850  | 1.315087 | .760406 |      |
|      | 652760 | 1.531957 | 861655    | 1.160567  | 1.320019 | .757565 |      |
| 41   | 656059 | 1.524253 | 869287    | 1.150388  | 1.325013 | .754710 | 49   |
|      | 659346 | 1.516655 | 876977    | 1.140292  | 1.330071 | .751840 |      |
|      | 662620 | 1.509161 | 884725    | 1.130294  | 1.335192 | .748956 |      |
|      | 665882 | 1.501768 | 892534    | 1.120405  | 1.340380 | .746057 |      |
| 42   | 669131 | 1.494477 | 900404    | 1.110613  | 1.345633 | .743145 | 48   |
|      | 672367 | 1.487283 | 908336    | 1.100914  | 1.350953 | .740218 |      |
|      | 675590 | 1.480187 | 916331    | 1.091309  | 1.356342 | .737277 |      |
|      | 678801 | 1.473186 | 924391    | 1.081794  | 1.361800 | .734323 |      |
| 43   | 681998 | 1.466279 | 932515    | 1.072369  | 1.367328 | .731354 | 47   |
|      | 685183 | 1.459464 | 940706    | 1.063031  | 1.372927 | .728371 |      |
|      | 688355 | 1.452740 | 948965    | 1.053780  | 1.378599 | .725374 |      |
|      | 691518 | 1.446104 | 957292    | 1.044614  | 1.384344 | .722364 |      |
| 44   | 694658 | 1.439557 | 965689    | 1.035530  | 1.390164 | .719340 | 46   |
|      | 697791 | 1.433095 | 974157    | 1.026529  | 1.396058 | .716302 |      |
|      | 700909 | 1.426718 | 982697    | 1.017607  | 1.402032 | .713250 |      |
|      | 704015 | 1.420425 | 991311    | 1.008755  | 1.408083 | .710185 |      |
| 45   | 707107 | 1.414214 | 1.000000  | 1.000000  | 1.414214 | .707107 | 45   |
| Deg. | Cosine | Secant   | Cotangent | Tangent   | Cosecant | Sine    | Deg. |

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME WELL-KNOWN CLIPPER SHIPS.

| SPECIES OF MASTS AND SPARS              | Length, 268 ft. Breadth, 27 ft. Tonnage, 1,348 |              |              | Length, 215 ft. Breadth, 26 ft. Tonnage, 1,333 |              |              | Length, 208 ft. Breadth, 26 ft. Tonnage, 1,159 |              |              |
|---|--|--------------|--------------|--|--------------|--------------|--|--------------|--------------|
|   | Fore Mast                                      | Main Mast    | Mizen Mast   | Fore Mast                                      | Main Mast    | Mizen Mast   | Fore Mast                                      | Main Mast    | Mizen Mast   |
| Lower mast.                             | 40 ft. 6 in.                                   | 48 ft. 0 in. | 46 ft. 6 in. | 46 ft. 0 in.                                   | 50 ft. 6 in. | 48 ft. 0 in. | 45 ft. 0 in.                                   | 47 ft. 6 in. | 43 ft. 0 in. |
| Head                                    | 15 ft. 6 in.                                   | 15 ft. 6 in. | 12 ft. 0 in. | 14 ft. 3 in.                                   | 14 ft. 3 in. | 11 ft. 0 in. | 12 ft. 0 in.                                   | 12 ft. 0 in. | 10 ft. 6 in. |
| Topmast.                                | 53 ft. 0 in.                                   | 53 ft. 0 in. | 53 ft. 0 in. | 48 ft. 0 in.                                   | 48 ft. 0 in. | 40 ft. 0 in. | 44 ft. 6 in.                                   | 44 ft. 6 in. | 50 ft. 6 in. |
| Head                                    | 9 ft. 0 in.                                    | 9 ft. 0 in.  | 6 ft. 6 in.  | 7 ft. 6 in.                                    | 7 ft. 6 in.  | 6 ft. 6 in.  | 7 ft. 6 in.                                    | 7 ft. 6 in.  | 7 ft. 0 in.  |
| Topgallant mast.                        | 24 ft. 0 in.                                   | 24 ft. 0 in. | 18 ft. 6 in. | 24 ft. 6 in.                                   | 24 ft. 6 in. | 28 ft. 0 in. | 21 ft. 6 in.                                   | 21 ft. 6 in. | 17 ft. 0 in. |
| Royal mast                              | 15 ft. 0 in.                                   | 15 ft. 0 in. | 10 ft. 6 in. | 18 ft. 0 in.                                   | 18 ft. 0 in. | 14 ft. 0 in. | 14 ft. 6 in.                                   | 14 ft. 6 in. | 11 ft. 0 in. |
| Skysail mast                            | —  | —            | —            | 13 ft. 0 in.                                   | 13 ft. 0 in. | 11 ft. 0 in. | —  | —            | —            |
| Pole                                    | 2 ft. 0 in.                                    | 2 ft. 0 in.  | 1 ft. 6 in.  | 1 ft. 0 in.                                    | 1 ft. 0 in.  | 1 ft. 0 in.  | 5 ft. 6 in.                                    | 5 ft. 6 in.  | 5 ft. 0 in.  |
| Whole length, arms included             | 86 ft. 0 in.                                   | 85 ft. 0 in. | 66 ft. 0 in. | 77 ft. 0 in.                                   | 77 ft. 0 in. | 66 ft. 0 in. | 78 ft. 6 in.                                   | 78 ft. 6 in. | 68 ft. 0 in. |
| Yard arms, each                         | 4 ft. 0 in.                                    | 4 ft. 0 in.  | 5 ft. 0 in.  | 2 ft. 9 in.                                    | 2 ft. 9 in.  | 2 ft. 6 in.  | 2 ft. 9 in.                                    | 2 ft. 9 in.  | 2 ft. 3 in.  |
| Lower topsail yard.                     | 63 ft. 0 in.                                   | 63 ft. 0 in. | 63 ft. 0 in. | 87 ft. 6 in.                                   | 87 ft. 6 in. | 56 ft. 0 in. | 62 ft. 0 in.                                   | 62 ft. 0 in. | 47 ft. 6 in. |
| Yard arms, each                         | 2 ft. 6 in.                                    | 2 ft. 6 in.  | 2 ft. 0 in.  | 3 ft. 6 in.                                    | 3 ft. 6 in.  | 3 ft. 0 in.  | 1 ft. 0 in.                                    | 1 ft. 6 in.  | 1 ft. 3 in.  |
| Upper topsail yard.                     | 55 ft. 0 in.                                   | 55 ft. 0 in. | 50 ft. 0 in. | 83 ft. 0 in.                                   | 83 ft. 0 in. | 50 ft. 0 in. | 57 ft. 6 in.                                   | 57 ft. 6 in. | 45 ft. 6 in. |
| Yard arms, each                         | 5 ft. 6 in.                                    | 5 ft. 6 in.  | 3 ft. 0 in.  | 2 ft. 0 in.                                    | 2 ft. 0 in.  | 2 ft. 0 in.  | 2 ft. 0 in.                                    | 2 ft. 0 in.  | 1 ft. 9 in.  |
| Topgallant yard.                        | 45 ft. 0 in.                                   | 45 ft. 0 in. | 38 ft. 0 in. | 50 ft. 0 in.                                   | 50 ft. 0 in. | 38 ft. 6 in. | 46 ft. 6 in.                                   | 46 ft. 6 in. | 35 ft. 0 in. |
| Yard arms, each                         | 2 ft. 0 in.                                    | 2 ft. 0 in.  | 1 ft. 9 in.  | 3 ft. 0 in.                                    | 3 ft. 0 in.  | 1 ft. 6 in.  | 2 ft. 3 in.                                    | 2 ft. 3 in.  | 1 ft. 3 in.  |
| Royal yard.                             | 32 ft. 6 in.                                   | 32 ft. 6 in. | 28 ft. 0 in. | 37 ft. 6 in.                                   | 37 ft. 6 in. | 28 ft. 6 in. | 38 ft. 0 in.                                   | 38 ft. 0 in. | 28 ft. 0 in. |
| Yard arms, each                         | 1 ft. 3 in.                                    | 1 ft. 3 in.  | 1 ft. 9 in.  | 1 ft. 6 in.                                    | 1 ft. 6 in.  | 1 ft. 0 in.  | 1 ft. 9 in.                                    | 1 ft. 9 in.  | 1 ft. 3 in.  |
| Skysail yard.                           | —  | —            | —            | 28 ft. 0 in.                                   | 28 ft. 0 in. | 20 ft. 0 in. | —  | —            | —            |
| Whole length, arms included             | 37 ft. 0 in.                                   | 37 ft. 0 in. | 35 ft. 0 in. | 1 ft. 0 in.                                    | 1 ft. 0 in.  | 0 ft. 0 in.  | —  | —            | —            |
| Yard arms, each                         | —  | —            | —            | —  | —            | —            | —  | —            | —            |
| Gaff.                                   | —  | —            | —            | —  | —            | —            | —  | —            | —            |
| Whole length, fly included              | —  | —            | —            | —  | —            | —            | —  | —            | —            |
| Spanker boom.                           | 25 ft. 0 in.                                   | —            | —            | 22 ft. 0 in.                                   | —            | —            | 21 ft. 6 in.                                   | —            | —            |
| Whole length                            | —  | —            | —            | —  | —            | —            | —  | —            | —            |
| Powerpit, exclusive of housing          | 51 ft. 0 in.                                   | —            | —            | 42 ft. 0 in.                                   | —            | —            | 38 ft. 0 in.                                   | —            | —            |
| Jibboom                                 | —  | —            | —            | —  | —            | —            | —  | —            | —            |
| Distance before aft side of main post † | —  | —            | —            | —  | —            | —            | —  | —            | —            |

† On load water-line.

\* Iron.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

| STRUCTURE OF MASTS AND SPARS                 | H.M.S. 'Warrior,' Ironclad.<br>Length, 220 ft. Breadth, 36 ft.<br>Tonnage, 4,100.<br>Ship-rigged |                 |                 |                 | Spanish Ironclad Frigate<br>'Victoria.'<br>Length, 316 ft. Breadth, 57 ft.<br>Tonnage, 4,383.<br>Ship-rigged |                     |                 |                 | H.M.S. 'Himalaya,'<br>Troopship.<br>Length, 350 ft. Breadth, 46 ft.<br>Tonnage, 3,400.<br>Ship-rigged |                 |                 |  |
|--|--|-----------------|-----------------|-----------------|--|---------------------|-----------------|-----------------|---|-----------------|-----------------|--|
|  | Fore Mast  | Main Mast       | Mizen Mast      | Fore Mast       | Main Mast  | Mizen Mast          | Fore Mast       | Main Mast       | Fore Mast   | Main Mast       | Mizen Mast      |  |
| Lower mast. From deck to braced trees        | ft. in. 60 5 33  | ft. in. 96 8 40 | ft. in. 64 6 26 | ft. in. 61 0 34 | ft. in. 64 0 34  | ft. in. 48 0 23 1/2 | ft. in. 58 0 31 | ft. in. 56 0 31 | ft. in. 56 0 31   | ft. in. 50 0 29 | ft. in. 50 0 29 |  |
| Head   | 19 0   | 20 0            | 13 0            | 18 0            | 16 0   | 12 6                | 14 6            | 14 6            | 14 6  | 11 0            | 11 0            |  |
| Topmast. Whole length, head included         | 85 0 23  | 65 0 22         | 60 8 18         | 62 6 18 1/2     | 62 6 18 1/2  | 39 0 12 1/2         | 61 0 17         | 51 0 17         | 51 0 17   | 37 0 12         | 37 0 12         |  |
| Head   | 8 9  | 9 9             | 6 9             | 6 6             | 6 6  | 6 0                 | 7 6             | 7 6             | 7 6   | 6 0             | 6 0             |  |
| Topgallant mast. From fid hole to hounds     | 81 6 12 1/2  | 31 6 17 1/2     | 23 6 9          | 26 0 9 1/2      | 26 0 9 1/2   | 20 0 6 1/2          | 23 6 10 1/2     | 23 6 10 1/2     | 23 6 10 1/2   | 18 6 7          | 18 6 7          |  |
| Royal mast                                   | 31 0   | 31 0            | 16 0            | 16 6            | 16 6   | 12 6                | 14 0            | 14 0            | 14 0  | 11 0            | 11 0            |  |
| Pole   | 4 0  | 4 0             | 2 6             | 6 0             | 6 0  | 4 0                 | 2 6             | 2 6             | 2 6   | 1 6             | 1 6             |  |
| Lower yard. Whole length, arms included      | 105 0 25   | 105 0 25        | 71 0 17         | 80 0 23         | 80 0 23  | 67 0 14 1/2         | 80 0 20         | 80 0 20         | 80 0 20   | 60 0 14 1/2     | 60 0 14 1/2     |  |
| Yard arms, each                              | 4 4  | 4 4             | 3 0             | 4 0             | 4 0  | 3 4                 | 4 0             | 4 0             | 4 0   | 3 0             | 3 0             |  |
| Topmast yard. Whole length, arms included    | 74 0 16  | 74 0 16         | 51 8 11 1/2     | 67 0 14 1/2     | 67 0 14 1/2  | 46 0 9 1/2          | 64 0 13         | 64 0 13         | 64 0 13   | 44 0 10         | 44 0 10         |  |
| Yard arms, each                              | 6 5  | 6 5             | 4 8             | 6 4             | 6 4  | 5 9                 | 8 0             | 8 0             | 8 0   | 6 6             | 6 6             |  |
| Topgallant yard. Whole length, arms included | 46 0 11  | 46 0 11         | 33 6 8          | 45 0 9 1/2      | 45 0 9 1/2   | 32 0 8              | 41 0 9 1/2      | 41 0 9 1/2      | 41 0 9 1/2  | 30 0 7          | 30 0 7          |  |
| Yard arms, each                              | 1 11   | 1 11            | 1 6             | 1 9             | 1 9  | 1 3                 | 3 6             | 3 6             | 3 6   | 1 3             | 1 3             |  |
| Royal yard. Whole length, arms included      | 33 6 6 1/2   | 22 6 6 1/2      | 24 6 6          | 30 0 6          | 30 0 6   | 21 6 4              | 20 0 6 1/2      | 20 0 6 1/2      | 20 0 6 1/2  | 27 6 5          | 27 6 5          |  |
| Yard arms, each                              | 1 4  | 1 4             | 1 0             | 1 3             | 1 3  | 1 0                 | 1 3             | 1 3             | 1 3   | 1 0             | 1 0             |  |
| Gaff. Whole length, fly included             | —  | —               | 49 0 11         | 53 6 9          | 41 6 8 1/2   | 44 0                | 24 6 5 1/2      | 24 6 5 1/2      | 24 6 5 1/2  | 37 0 9          | 37 0 9          |  |
| Fly  | —  | —               | 3 6             | 3 0             | 1 8  | 6 6                 | 3 6             | 3 6             | 3 6   | 4 0             | 4 0             |  |
| Spunker boom. Whole length                   | —  | —               | 70 0 16         | —               | —  | —                   | —               | —               | —   | 56 0 13         | 56 0 13         |  |
| Bowsprit, exclusive of housing               | 49 0 40  | —               | —               | 33 6 34         | —  | —                   | —               | —               | —   | —               | —               |  |
| Jibboom, housing included                    | 49 0 16  | —               | —               | 46 0 16         | —  | —                   | —               | —               | —   | —               | —               |  |
| Housing                                      | 16 6   | —               | —               | 16 6            | —  | —                   | —               | —               | —   | —               | —               |  |
| Distance before aft side of stern post †     | 216 0  | 162 0           | 61 6            | 145 6           | 136 6  | 53 0                | 141 6           | 131 9           | 131 9   | 40 0            | 40 0            |  |

† Of iron, 1 1/2 to 2 in. thick.

† Of iron, 1 1/2 to 2 in. thick.

† On high water line.

**TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (continued).**

| SPECIES OF MASTS AND SPARS                    | Merchant Steamer "Pera,"<br>Length, 265 ft. Breadth, 42 ft.<br>Tonnage, 1,400.<br>Ship-rigged. |                 |                 |                  | H.M.S. "Rover," Corvett<br>Length, 204 ft. Breadth, 42 ft. 6 in.<br>Tonnage, 1,335.<br>Ship-rigged. |                  |                 |                 | H.M.S. "Diamond," Corvette.<br>Length, 220 ft. Breadth, 40 ft.<br>Tonnage, 1,289.<br>Ship-rigged. |                 |                 |                 |
|---|--|-----------------|-----------------|------------------|---|------------------|-----------------|-----------------|---|-----------------|-----------------|-----------------|
|   | Fore Mast  | Main Mast       | Mizen Mast      | Fore Mast        | Main Mast   | Mizen Mast       | Fore Mast       | Main Mast       | Mizen Mast  | Fore Mast       | Main Mast       | Mizen Mast      |
| Lower mast. From deck to trussel trees.       | ft. in. 65 0 32  | ft. in. 60 6 32 | ft. in. 51 0 22 | ft. in. 59 6 29* | ft. in. 57 6 31*  | ft. in. 45 6 22† | ft. in. 49 6 22 | ft. in. 53 0 23 | ft. in. 43 0 13   | ft. in. 49 6 22 | ft. in. 53 0 23 | ft. in. 43 0 13 |
| Head  | 16 0   | 13 0            | 11 0            | 14 0             | 14 0  | 10 0             | 13 0            | 13 0            | 7 6   | 13 0            | 13 0            | 7 6             |
| Topmast. Whole length, head included.         | 45 0 17  | 45 0 17         | 35 6 13         | 43 6 18          | 45 6 18   | 41 0 13‡         | 43 0 13‡        | 43 0 13‡        | 31 0 11   | 43 0 13‡        | 43 0 13‡        | 31 0 11         |
| Head  | 7 2  | 7 3             | 5 6             | 1 6              | 8 6   | 8 6              | 6 0             | 6 0             | 6 0   | 6 0             | 6 0             | 6 0             |
| Topgallant mast. From old hole to hounds.     | 23 0 11  | 25 0 11         | 19 6 7‡         | 23 0 10          | 25 0 10   | 19 6 8           | 20 6 8          | 20 6 8          | 16 0 6‡   | 20 6 8          | 20 6 8          | 16 0 6‡         |
| Royal mast.                                   | 12 0   | 12 0            | 9 0             | 11 6             | 12 6  | 12 0             | 11 0            | 11 0            | 8 6   | 11 0            | 11 0            | 8 6             |
| Pole  | 2 6  | 2 6             | 1 6             | 1 6              | 3 6   | 3 0              | 2 6             | 2 6             | 2 0   | 2 6             | 2 6             | 2 0             |
| Lower yard. Whole length, arms included.      | 85 0 17  | 80 0 17         | 60 0 13         | 73 6 19          | 78 6 19   | 65 0 13          | 67 0 16         | 67 0 16         | 43 0 10   | 67 0 16         | 67 0 16         | 43 0 10         |
| Yard arms, each                               | 4 8  | 4 8             | 4 0             | 1 4              | 3 4   | 2 4              | 2 6             | 2 9             | 1 10  | 2 9             | 2 9             | 1 10            |
| Topseal yard. Whole length, arms included.    | 51 0 13  | 61 0 13         | 45 0 10         | 59 0 13          | 69 0 13   | 42 0 9‡          | 43 6 10‡        | 49 6 10‡        | 34 0 8  | 43 6 10‡        | 49 6 10‡        | 34 0 8          |
| Yard arms, each                               | 5 0  | 5 0             | 4 6             | 4 11             | 4 11  | 3 7              | 4 6             | 4 8             | 3 0   | 4 8             | 4 8             | 3 0             |
| Topgallant yard. Whole length, arms included. | 41 0 8   | 41 0 8          | 23 0 5‡         | 40 0 9‡          | 40 0 9‡   | 30 6 7‡          | 32 0 7          | 32 0 7          | 22 0 5‡   | 32 0 7          | 32 0 7          | 22 0 5‡         |
| Yard arms, each                               | 3 6  | 3 6             | 1 0             | 1 8              | 1 8   | 1 2              | 1 4             | 1 4             | 1 1   | 1 4             | 1 4             | 1 1             |
| Royal yard. Whole length, arms included.      | 28 0 6   | 26 0 6          | 14 0 3‡         | 29 6 6           | 29 6 6  | 23 0 3‡          | 24 0 3          | 24 0 3          | 17 0 3‡   | 24 0 3          | 24 0 3          | 17 0 3‡         |
| Yard arms, each                               | 1 3  | 1 3             | 1 0             | 1 3              | 1 3   | 1 0              | 1 0             | 1 0             | 8   | 1 0             | 1 0             | 8               |
| Gall. Whole length, fly included.             | 35 0 9‡  | 35 0 9‡         | 27 6 9‡         | 35 0 9‡          | 35 0 9‡   | 29 0 9‡          | 32 0 9‡         | 32 0 9‡         | 24 0 8  | 32 0 9‡         | 32 0 9‡         | 24 0 8          |
| Fly   | 2 6  | 2 6             | 6 6             | 3 0              | 3 0   | 2 0              | 2 0             | 2 0             | 2 0   | 2 0             | 2 0             | 2 0             |
| Spanker boom. Whole length                    | —  | —               | 54 0 13         | —                | —   | 55 6 13          | —               | —               | —   | —               | —               | —               |
| Boomsprit, exclusive of housing               | 23 6 30  | —               | 18 0 24         | —                | —   | —                | 19 6 18         | —               | —   | —               | —               | —               |
| Jibboom, housing included                     | 67 6 14‡   | —               | —               | —                | —   | —                | —               | —               | —   | —               | —               | —               |
| Housing                                       | 28 6   | —               | —               | —                | —   | —                | —               | —               | —   | —               | —               | —               |
| Distance before aft side of stern post ‡      | 343 0  | 125 6           | 13 6            | 233 0            | 123 6   | 45 9             | 176 0           | 91 6            | 26 0  | 176 0           | 91 6            | 26 0            |

\* Iron, 1½ in. thick.

† Iron, 3 in. thick.

‡ On load water line.



TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT—  
BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (continued).

| SPECIES OF MASTS AND SPARS                   | Turkish Ironclad, Sultan Mahmud.                               |           |            |           |           |            | H.M.S. 'Scrapie,' Troopship.                                   |           |            |           |           |            | H.M.S. 'Vallant,' Ironclad.                                    |           |            |           |           |            |
|--|--|-----------|------------|-----------|-----------|------------|--|-----------|------------|-----------|-----------|------------|--|-----------|------------|-----------|-----------|------------|
|  | Length, 233 ft. Breadth, 56 ft. Tonnage, 4,375. Barque-rigged. |           |            |           |           |            | Length, 360 ft. Breadth, 45 ft. Tonnage, 4,173. Barque-rigged. |           |            |           |           |            | Length, 360 ft. Breadth, 56 ft. Tonnage, 4,000. Barque-rigged. |           |            |           |           |            |
|  | Fore Mast  | Main Mast | Mizen Mast | Fore Mast | Main Mast | Mizen Mast | Fore Mast  | Main Mast | Mizen Mast | Fore Mast | Main Mast | Mizen Mast | Fore Mast  | Main Mast | Mizen Mast | Fore Mast | Main Mast | Mizen Mast |
| Lower mast. From deck to trussel trees       | ft. 67   | in. 36    | ft. 83     | in. 38    | ft. 55    | in. 24     | ft. 49   | in. 30    | ft. 54     | in. 32    | ft. 57    | in. 18     | ft. 57   | in. 18    | ft. 57     | in. 18    | ft. 57    | in. 18     |
| Topmast. Head                                | 16   | 0         | 16         | 0         | 13        | 8          | 14   | 0         | 15         | 0         | 10        | 0          | 20   | 0         | 20         | 0         | 20        | 0          |
| Topmast. Whole length, head included         |  |           |            |           |           |            | 46   | 6         | 46         | 6         | 46        | 6          | 46   | 6         | 46         | 6         | 46        | 6          |
| Topmast. Length to stops                     |  |           |            |           |           |            | 22   | 6         | 22         | 6         | 22        | 6          | 22   | 6         | 22         | 6         | 22        | 6          |
| Topgallant mast. Length to stops             |  |           |            |           |           |            | 14   | 0         | 14         | 0         | 14        | 0          | 14   | 0         | 14         | 0         | 14        | 0          |
| Royal mast. Pole.                            |  |           |            |           |           |            | 22   | 6         | 22         | 6         | 22        | 6          | 22   | 6         | 22         | 6         | 22        | 6          |
| Lower yard. Whole length, arms included.     | 91   | 0         | 91         | 0         | 91        | 0          | 80   | 8         | 80         | 8         | 80        | 8          | 80   | 8         | 80         | 8         | 80        | 8          |
| Yard arms, each                              | 3  | 6         | 3          | 6         | 3         | 6          | 3  | 6         | 3          | 6         | 3         | 6          | 3  | 6         | 3          | 6         | 3         | 6          |
| Topmast yard. Whole length, arms included    | 70   | 0         | 70         | 0         | 70        | 0          | 65   | 0         | 65         | 0         | 65        | 0          | 65   | 0         | 65         | 0         | 65        | 0          |
| Gaff topsail yard. Whole length.             | 3  | 10        | 3          | 10        | 3         | 10         | 3  | 10        | 3          | 10        | 3         | 10         | 3  | 10        | 3          | 10        | 3         | 10         |
| Yard arms, each                              | 44   | 0         | 44         | 0         | 44        | 0          | 40   | 0         | 40         | 0         | 40        | 0          | 40   | 0         | 40         | 0         | 40        | 0          |
| Topgallant yard. Whole length, arms included | 2  | 0         | 2          | 0         | 2         | 0          | 2  | 0         | 2          | 0         | 2         | 0          | 2  | 0         | 2          | 0         | 2         | 0          |
| Yard arms, each                              | 38   | 0         | 38         | 0         | 38        | 0          | 36   | 0         | 36         | 0         | 36        | 0          | 36   | 0         | 36         | 0         | 36        | 0          |
| Royal yard. Whole length, arms included      | 38   | 0         | 38         | 0         | 38        | 0          | 36   | 0         | 36         | 0         | 36        | 0          | 36   | 0         | 36         | 0         | 36        | 0          |
| Yard arms, each                              | 24   | 6         | 24         | 6         | 24        | 6          | 20   | 0         | 20         | 0         | 20        | 0          | 20   | 0         | 20         | 0         | 20        | 0          |
| Gaff. Whole length, fly included.            | 59   | 0         | 59         | 0         | 59        | 0          | 58   | 0         | 58         | 0         | 58        | 0          | 58   | 0         | 58         | 0         | 58        | 0          |
| Spanker boom. Whole length                   | 24   | 6         | 24         | 6         | 24        | 6          | 20   | 0         | 20         | 0         | 20        | 0          | 20   | 0         | 20         | 0         | 20        | 0          |
| Bowsprit, exclusive of bonking               | 59   | 0         | 59         | 0         | 59        | 0          | 58   | 0         | 58         | 0         | 58        | 0          | 58   | 0         | 58         | 0         | 58        | 0          |
| Jibboom, bonking included                    | 239  | 6         | 239        | 6         | 239       | 6          | 236  | 9         | 236        | 9         | 236       | 9          | 236  | 9         | 236        | 9         | 236       | 9          |
| Distances before aft side of stern post **   |  |           |            |           |           |            |  |           |            |           |           |            |  |           |            |           |           |            |

\* Of iron,  $\frac{1}{2}$  in. thick. † Of iron,  $\frac{1}{2}$  in. thick. ‡ Of steel,  $\frac{1}{2}$  in. thick. § Of lead, 100 lb. each. || Of lead, 100 lb. each.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (continued).

| SPARS OF MASTS AND SPARS                 | 'Mooltan,' Merchant Steamer.<br>Length, 125 ft. Breadth, 30 ft.<br>Tonnage, 2,371.<br>Barque-rigged. |             |            |  | 'Europa,' Merchant Steamer.<br>Length, 225 ft. Breadth, 20 ft. 6 in.<br>Tonnage, 1,024.<br>Barque-rigged. |             |             |  | 'General Monellan,' Merchant Steamer.<br>Length, 200 ft. Breadth, 20 ft.<br>Tonnage, 815.<br>Barque-rigged. |            |            |  |
|--|--|-------------|------------|--|---|-------------|-------------|--|---|------------|------------|--|
|  | Fore Mast  | Main Mast   | Mizen Mast |  | Fore Mast   | Main Mast   | Mizen Mast  |  | Fore Mast   | Main Mast  | Mizen Mast |  |
| Lower mast                               | ft. in.  | ft. in.     | ft. in.    |  | ft. in.   | ft. in.     | ft. in.     |  | ft. in.   | ft. in.    | ft. in.    |  |
| Head                                     | 53 0 82  | 55 0 32     | 47 0 27    |  | 44 0 27   | 49 0 27     | 48 0 15     |  | 44 0 18   | 49 0 15    | 39 0 12    |  |
| Whole length, head included              | 14 6   | 14 6        | 11 0       |  | 12 0  | 12 0        | 8 0         |  | 11 0  | 11 0       | 8 0        |  |
| Topmast.                                 | 46 0 17  | 46 0 17     |            |  | 36 0 14   | 36 0 14     |             |  |   |            |            |  |
| Head                                     | 7 0  | 7 0         |            |  | 6 0   | 6 0         |             |  |   |            |            |  |
| Length to stops                          |  |             | 32 0 13    |  |   |             | 47 0 10 1/2 |  |   |            |            |  |
| Topgallant mast.                         | 24 0 11  | 24 0 11     |            |  | 19 0 7 1/2  | 19 0 7 1/2  |             |  | 25 3 11   | 25 3 11    | 27 6 7 1/2 |  |
| Royal mast                               | 15 0   | 15 0        |            |  | 14 6  | 14 6        |             |  | 15 0  | 15 0       |            |  |
| Pole                                     | 6 0  | 6 0         |            |  | 4 6   | 4 6         |             |  | 7 0   | 7 0        | 8 0        |  |
| Lower yard.                              | 75 0 17  | 75 0 17     |            |  | 70 0 10 1/2   | 70 0 10 1/2 | 4 0         |  | 64 0 13   | 64 0 13    |            |  |
| Whole length, arms included              | 5 0  | 5 0         |            |  | 8 0   | 8 0         |             |  | 8 6   | 8 6        |            |  |
| Yard arms, each                          | 57 0 12 1/2  | 57 0 12 1/2 |            |  | 55 0 12 1/2   | 55 0 12 1/2 |             |  | 43 0 9 1/2  | 49 0 9 1/2 |            |  |
| Whole length.                            |  |             |            |  |   |             |             |  |   |            | 15 6 4 1/2 |  |
| Gaff topsail yard.                       | 6 0  | 6 0         |            |  | 4 0   | 4 0         |             |  | 4 0   | 4 0        |            |  |
| Yard arms, each                          | 36 0 7 1/2   | 38 0 7 1/2  |            |  | 29 0 7 1/2  | 38 0 7 1/2  |             |  | 28 8 6 1/2  | 28 8 6 1/2 |            |  |
| Topgallant yard.                         | 3 0  | 3 0         |            |  | 3 6   | 3 6         |             |  | 3 0   | 3 0        |            |  |
| Whole length, arms included              |  |             |            |  | 26 0 6  | 26 0 6      |             |  |   |            |            |  |
| Royal yard.                              |  |             |            |  | 1 6   | 1 6         |             |  |   |            |            |  |
| Whole length, arms included              |  |             |            |  | 33 0 9 1/2  | 33 0 9 1/2  |             |  | 31 0 8  | 31 0 8     |            |  |
| Gaff                                     | 33 6 9 1/2   | 39 6 9 1/2  | 33 6 9 1/2 |  | 33 0 9 1/2  | 33 0 9 1/2  | 29 0 8 1/2  |  | 31 0 8  | 31 0 8     | 30 0 7 1/2 |  |
| Whole length, 1/2 included               |  |             | 23 0 11    |  |   |             | 49 0 10 1/2 |  |   |            | 41 0 9     |  |
| Spanker boom.                            |  |             |            |  | 27 0 26   |             |             |  | 18 9 17   |            |            |  |
| Whole length                             | 23 0 30  |             |            |  | 24 0 14   |             |             |  | 25 0 8  |            |            |  |
| Booseprit, exclusive of housing          | 26 0 14 1/2  |             |            |  | 177 0   |             |             |  | 154 0   |            |            |  |
| Jibboom                                  | 268 0  | 144 6       | 55 3       |  | 177 0   | 98 0        | 34 0        |  | 83 6  |            | 83 0       |  |
| Distance before aft side of stern post † |  |             |            |  |   |             |             |  |   |            |            |  |

† On load water-line.

\* Jib-headed topsail on mizen mast.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME MERCHANT VESSELS BUILT BY  
THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

| SPECIES OF MASTS AND SPARS                  | Sailing Vessel, 'Haddington.'<br>Length, 200 ft. Breadth, 25 ft. 6 in.<br>Tonnage, 1,250.<br>Burque-rigged |        |           |        | Screw Steamer<br>'Tanjore.'<br>Length, 200 ft.<br>Breadth, 28 ft.<br>Tonnage, 2,150 |        |           |        | Screw Steamer<br>'Charleth.'<br>Length, 200 ft.<br>Breadth, 26 ft.<br>Tonnage, 2,507 |        |           |        | Sailing Vessel<br>'Maitland.'<br>Length, 125 ft.<br>Breadth, 20 ft.<br>Tonnage, 250 |        |           |        |
|---|--|--------|-----------|--------|---|--------|-----------|--------|--|--------|-----------|--------|---|--------|-----------|--------|
|   | Fore Mast  |        | Main Mast |        | Fore Mast   |        | Main Mast |        | Fore Mast  |        | Main Mast |        | Fore Mast   |        | Main Mast |        |
|   | ft. in.  | in.    | ft. in.   | in.    | ft. in.   | in.    | ft. in.   | in.    | ft. in.  | in.    | ft. in.   | in.    | ft. in.   | in.    | ft. in.   | in.    |
| Lower mast. From deck to trussel trees      | 52 0   | 81     | 58 0      | 81     | 50 0  | 30     | 58 0      | 80     | 46 0   | 27     | 51 0      | 27     | 49 6  | 18     | 51 0      | 18     |
| Head  | 15 6   | —      | 15 6      | —      | 14 0  | —      | 14 0      | —      | 12 6   | —      | 12 0      | —      | 9 6   | —      | 9 6       | —      |
| Topmast. Whole length, head included        | 52 6   | 17     | 58 6      | 17     | 50 6  | 17     | 58 6      | 17     | 48 6   | 14     | 51 6      | 14     | 48 6  | 14     | 51 6      | 14     |
| Head  | 2 6  | —      | 2 6       | —      | 2 0   | —      | 2 0       | —      | 2 6  | —      | 2 0       | —      | 2 6   | —      | 2 0       | —      |
| Topmast. Length to stops                    | 50 0   | —      | 56 0      | —      | 48 0  | —      | 56 0      | —      | 46 0   | —      | 49 0      | —      | 46 0  | —      | 49 0      | —      |
| Topgallant mast. Length to stops            | 24 6   | 10 1/2 | 24 6      | 10 1/2 | 24 6  | 11 1/2 | 24 6      | 11 1/2 | 21 6   | 10 1/2 | 21 6      | 10 1/2 | 18 6  | 10 1/2 | 18 6      | 10 1/2 |
| Royal mast                                  | 14 6   | —      | 14 6      | —      | 18 0  | —      | 18 0      | —      | 11 6   | —      | 11 6      | —      | 8 6   | —      | 8 6       | —      |
| Pole  | 3 6  | —      | 3 6       | —      | 3 6   | —      | 3 6       | —      | 4 0  | —      | 4 0       | —      | 2 6   | —      | 2 6       | —      |
| Lower yard. Whole length, arms included     | 54 0   | 20     | 54 0      | 20     | 48 0  | —      | 58 0      | 14     | 40 0   | —      | 55 0      | 13     | 36 6  | 12     | 36 6      | 12     |
| Yard arms, each                             | 4 0  | —      | 4 0       | —      | 5 0   | —      | 5 0       | —      | 5 0  | —      | 5 0       | —      | 2 0   | —      | 2 0       | —      |
| Topmast yard. Whole length, arms included   | 44 0   | 15     | 44 0      | 15     | 38 0  | —      | 48 0      | 14     | 30 0   | —      | 40 0      | 13     | 25 6  | 12     | 25 6      | 12     |
| Yard arms, each                             | 5 0  | —      | 5 0       | —      | 6 0   | —      | 6 0       | —      | 6 0  | —      | 6 0       | —      | 2 0   | —      | 2 0       | —      |
| Topgallant yard. Whole length arms included | 42 0   | 10     | 42 0      | 10     | 36 0  | —      | 46 0      | 9      | 28 0   | —      | 38 0      | 8      | 20 6  | 8      | 20 6      | 8      |
| Yard arms, each                             | 3 0  | —      | 3 0       | —      | 3 0   | —      | 3 0       | —      | 3 0  | —      | 3 0       | —      | 1 0   | —      | 1 0       | —      |
| Royal yard. Whole length, arms included     | 50 0   | 7      | 50 0      | 7      | 40 0  | —      | 50 0      | —      | 30 0   | —      | 40 0      | —      | 18 6  | 4      | 18 6      | 4      |
| Yard arms, each                             | 1 3  | —      | 1 3       | —      | 1 3   | —      | 1 3       | —      | 1 3  | —      | 1 3       | —      | 1 0   | —      | 1 0       | —      |
| Gaff. Whole length                          | 33 6   | 11     | 33 6      | 11     | 40 0  | —      | 40 0      | —      | 36 6   | 8      | 36 6      | 8      | 1 0   | —      | 1 0       | —      |
| Ply   | 2 6  | —      | 2 6       | —      | 5 6   | —      | 5 6       | —      | 5 0  | —      | 5 0       | —      | —   | —      | —         | —      |
| Spencer boom                                | —  | —      | —         | —      | —   | —      | —         | —      | —  | —      | —         | —      | —   | —      | —         | —      |
| Flowsprit, exclusive of housing             | 56 0   | 80     | —         | —      | 43 0  | 36     | —         | —      | 36 0   | 28     | —         | —      | 34 6  | 18     | —         | —      |
| Stretcher                                   | 24 0   | 14     | —         | —      | —   | —      | —         | —      | —  | —      | —         | —      | 26 0  | 10     | —         | —      |
| Stretcher before aft side of stern post     | 17 6   | —      | —         | —      | —   | —      | —         | —      | —  | —      | —         | —      | 87 0  | —      | —         | —      |

ft. in. 1/2 in. 3/4 in.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAMERS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

| SPECIES OF MASTS AND SPARS               | "Vasco de Gama,"<br>Portuguese Brigadeer,<br>Length, 300 ft. Breadth, 40 ft.<br>Tonnage, 1,497.<br>3-masted Schooner |           |            |           | "Alexandria,"<br>Merchant Steamer,<br>Length, 210 ft. Breadth, 30 ft.<br>Tonnage, 919.<br>3-masted Schooner |            |           |           | H.M.S. "Swift,"<br>Composite Gunboat,<br>Length, 155 ft. Breadth, 30 ft.<br>Tonnage, 690.<br>3-masted Schooner |           |           |            |
|--|--|-----------|------------|-----------|---|------------|-----------|-----------|--|-----------|-----------|------------|
|  | Fore Mast  | Main Mast | Mizen Mast | Fore Mast | Main Mast   | Mizen Mast | Fore Mast | Main Mast | Mizen Mast   | Fore Mast | Main Mast | Mizen Mast |
| Lower mast. Deck to trussel trees        | 40 0 22  | 40 0 22   | 41 0 16    | 44 0 18   | 47 0 18   | 47 0 18    | 38 0 16   | 41 0 16   | 41 0 16  | 38 0 16   | 41 0 16   | 41 0 16    |
| Topmast. Head                            | 10 0 1   | 10 0 1    | 7 0 0      | 10 0 1    | 10 0 1  | 8 6 0      | 7 8 0     | 7 8 0     | 7 8 0  | 7 8 0     | 7 8 0     | 7 8 0      |
| Topmast. Length to steps                 | 27 0 12  | 28 6 11   | 31 0 2     | 26 6 10   | 41 0 9  | 25 6 8     | 19 6 8    | 21 6 8    | 21 6 8   | 19 6 8    | 21 6 8    | 24 6 5     |
| Topmast. Topgallant mast.                | 18 6 1   | —         | —          | 16 6      | —   | —          | 10 0      | —         | —  | 10 0      | —         | —          |
| Royal mast.                              | —  | —         | —          | —         | —   | —          | —         | —         | —  | —         | —         | —          |
| Pole                                     | —  | —         | —          | —         | —   | —          | —         | —         | —  | —         | —         | —          |
| Lower yard. Whole length                 | 26 6   | 6 6       | 5 0        | 5 0       | 6 0   | 5 6        | 4 0       | —         | —  | 4 0       | —         | 5 0        |
| Lower yard. Yard arms, each              | 60 6 14  | —         | —          | 55 0 14   | —   | —          | 2 0       | —         | —  | —         | —         | —          |
| Topmast yard. Whole length               | 3 0  | —         | —          | 4 0       | —   | —          | —         | —         | —  | —         | —         | —          |
| Gaff topsail yard. Whole length          | 41 0 10  | —         | —          | 49 0 10   | —   | —          | 32 6 7    | —         | —  | —         | —         | —          |
| Topgallant yard. Yard arms, each         | 8 0  | 20 0 6    | 14 0 4     | 8 6       | 10 0 6  | 15 6 5     | 2 0       | —         | —  | —         | —         | —          |
| Topgallant yard. Whole length            | 26 0 7   | 2 6       | 1 6        | 32 6 7    | 2 1   | 1 6        | 20 0 4    | —         | —  | —         | —         | —          |
| Royal yard. Whole length                 | 1 9  | —         | —          | 2 8       | —   | —          | 1 2       | —         | —  | —         | —         | —          |
| Gaff. Whole length, fly included         | 29 0 8   | 29 0 8    | 24 0 8     | 31 0 8    | 35 0 8  | 27 0 8     | 22 0 8    | —         | —  | —         | —         | —          |
| Fly                                      | 2 0  | 2 0       | 1 6        | 2 0       | 2 0   | 1 6        | 1 0       | —         | —  | —         | —         | —          |
| Boom. Whole length                       | —  | —         | 34 0 8     | 42 6 10   | 47 0 10   | 38 6 9     | 16 0 13   | —         | —  | —         | —         | —          |
| Boom. Whole length, exclusive of housing | 16 0 17  | —         | —          | 22 0 18   | —   | —          | 15 0      | —         | —  | —         | —         | —          |
| Boom. Whole length                       | 41 0 11  | —         | —          | 22 0 18   | —   | —          | 15 0      | —         | —  | —         | —         | —          |
| Boom. Whole length                       | 141 0  | 88 0      | 22 0       | 161 0     | 91 0  | 29 6       | 134 0     | 64 6      | —  | —         | —         | 17 3       |

† On load water line.

† Jib-headed topsail.

\* Of iron.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCHOONER-RIGGED STEAMERS.

| SPECIES OF MASTS AND SPARS            | Length, 150 ft.<br>Breadth, 30 ft.<br>Tonnage 480<br>Schooner-rigged * |           |           | Length, 130 ft.<br>Breadth, 30 ft.<br>Tonnage, 251<br>Schooner-rigged |           |           | Length, 108 ft.<br>Breadth, 17 ft. 6 in.<br>Tonnage, 169<br>Schooner-rigged |           |           | Length, 76 ft.<br>Breadth, 13 ft.<br>Tonnage, 80<br>Fore and Aft Schooner |           |           |
|---------------------------------------|--|-----------|-----------|---|-----------|-----------|---|-----------|-----------|---|-----------|-----------|
|                                       | Fore Mast  | Main Mast | Fore Mast | Main Mast   | Fore Mast | Main Mast | Fore Mast   | Main Mast | Fore Mast | Main Mast   | Fore Mast | Main Mast |
|                                       | Lgth.  | Dia.      | Lgth.     | Dia.  | Lgth.     | Dia.      | Lgth.   | Dia.      | Lgth.     | Dia.  | Lgth.     | Dia.      |
| Lower mast. From deck to hounds Head. | 42 6   | 15        | 44 0      | 14  | 39 0      | 15        | 37 0  | 14        | 38 0      | 13  | 28 6      | 11        |
| Topmast. Length to stops Pole         | 10 0   | —         | 10 0      | —   | 8 0       | —         | 7 6   | —         | 7 6       | —   | —         | —         |
| Topgallant mast. Length to stops Pole | 21 0   | 10        | 36 6      | 9   | 30 0      | 7         | 26 0  | 9         | 27 0      | 9   | 20 0      | —         |
| Lower yard. Whole length              | 12 6   | —         | 3 6       | —   | 10 0      | —         | 3 0   | —         | 3 0       | —   | 4 0       | —         |
| Yard arms, each                       | 8 0  | —         | —         | —   | 4 0       | —         | —   | —         | —         | —   | —         | —         |
| Topmast. Whole length                 | 60 0   | 10 1/2    | —         | —   | 48 0      | 6         | 41 0  | 9 1/2     | —         | —   | —         | —         |
| Topgallant yard. Whole length         | 3 0  | —         | —         | —   | 2 0       | —         | 2 0   | —         | —         | —   | —         | —         |
| Gaff topsail yard. Whole length       | 44 6   | 8         | —         | —   | 34 0      | 7         | 24 0  | 8         | 18 0      | 11  | 13 0      | 4 1/2     |
| Yard arms, each                       | 4 0  | —         | 14 0      | 5   | 2 6       | —         | 2 0   | —         | 2 0       | —   | 1 6       | —         |
| Topgallant yard. Whole length         | 29 0   | 5 1/2     | —         | —   | 21 0      | 6         | —   | —         | —         | —   | —         | —         |
| Gaff. Whole length, fly included      | 31 0   | 5 1/2     | 34 0      | 6 1/2   | 19 0      | 6         | 26 0  | 7 1/2     | 26 0      | 7 1/2   | 18 6      | 6 1/2     |
| Spanker boom                          | 2 0  | —         | 2 0       | —   | 2 0       | —         | 2 6   | —         | 3 0       | —   | 2 0       | —         |
| Boomsprit, exclusive of housing       | —  | —         | 58 0      | 11  | —         | —         | —   | —         | 28 0      | 7   | 28 0      | 7         |
| Jibboom                               | —  | —         | —         | —   | —         | —         | —   | —         | —         | —   | —         | —         |
| Housing                               | —  | —         | —         | —   | 13 0      | 12        | —   | —         | —         | —   | —         | —         |
| Distance before reader post †         | —  | —         | —         | —   | 15 0      | 5         | —   | —         | —         | —   | —         | —         |
|                                       | 114 0  | —         | 45 6      | —   | 98 6      | —         | 81 6  | —         | 84 3      | —   | 57 0      | —         |

\* On load water-line.

† Moors of war.

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS.

| SPECIES OF MASTS AND SPARS |        |                               | Clipper Ships |       | Ironclad Frigates |       | Wood-sheathed Corvette |       | Troop-sloop | Merchant Steamer |
|----------------------------|--------|-------------------------------|---------------|-------|-------------------|-------|------------------------|-------|-------------|------------------|
|                            |        |                               | Ex. 1         | Ex. 2 | Ex. 1             | Ex. 2 |                        |       |             |                  |
| Main mast                  | banded | = breadth of vessel           | 1-389         | 1-403 | 1-141             | 947   | 1-238                  | 1-217 | 1-440       |                  |
| "                          | headed | = banded length               | 254           | 282   | 302               | 333   | 289                    | 259   | 249         |                  |
| Fore "                     | banded | = main mast banded            | 910           | 911   | 908               | 944   | 904                    | 916   | 958         |                  |
| "                          | headed | = banded length               | 281           | 309   | 315               | 353   | 298                    | 273   | 259         |                  |
| Mizen "                    | banded | = main mast banded            | 905           | 911   | 823               | 889   | 875                    | 893   | 843         |                  |
| "                          | headed | = banded length               | 246           | 289   | 239               | 260   | 219                    | 222   | 215         |                  |
| Main topmast               | banded | = breadth of vessel           | 1-086         | 1-125 | 987               | 808   | 1-000                  | 945   | 976         |                  |
| "                          | headed | = banded length               | 211           | 185   | 155               | 141   | 155                    | 172   | 167         |                  |
| Fore "                     | banded | = main topmast banded         | 1-000         | 1-000 | 1-000             | 1-000 | 1-000                  | 1-000 | 1-000       |                  |
| "                          | headed | = banded length               | 211           | 185   | 155               | 141   | 155                    | 172   | 167         |                  |
| Mizen "                    | banded | = main topmast banded         | 803           | 827   | 777               | 739   | 774                    | 736   | 782         |                  |
| "                          | headed | = banded length               | 238           | 194   | 154               | 147   | 154                    | 156   | 183         |                  |
| Main topgallant            | banded | = breadth of vessel           | 632           | 958   | 545               | 456   | 595                    | 511   | 548         |                  |
| "                          | headed | = breadth of vessel           | 426           | 500   | 362               | 289   | 369                    | 305   | 286         |                  |
| royal                      | "      | "                             | 379           | —     | 191               | 864   | 096                    | 178   | 208         |                  |
| "                          | "      | "                             | —             | 361   | —                 | —     | —                      | —     | —           |                  |
| "                          | "      | "                             | —             | 077   | —                 | —     | —                      | —     | —           |                  |
| Fore topgallant            | "      | "                             | 1-000         | 1-000 | 1-000             | 1-000 | 1-000                  | 1-000 | 1-000       |                  |
| "                          | headed | = main topgallant mast banded | 1-000         | 1-000 | 1-000             | 1-000 | 1-000                  | 1-000 | 1-000       |                  |
| royal                      | "      | "                             | 379           | —     | 191               | 864   | 096                    | 178   | 208         |                  |
| "                          | "      | "                             | —             | 1-000 | —                 | —     | —                      | —     | —           |                  |
| "                          | "      | "                             | —             | 077   | —                 | —     | —                      | —     | —           |                  |
| Mizen topgallant           | "      | "                             | 500           | 826   | 746               | 769   | 780                    | 798   | 849         |                  |
| "                          | headed | = main topgallant mast banded | 823           | 778   | 762               | 818   | 774                    | 786   | 790         |                  |
| royal                      | "      | "                             | —             | —     | —                 | —     | —                      | —     | —           |                  |

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS  
(continued).

| SPECIES OF MASTS AND SPARS                               | Cutter Ships |       | Ironclad Frigates |       | Screw Vessels          |                        | Troop-ship | Merchant Steamer |
|--|--------------|-------|-------------------|-------|------------------------|------------------------|------------|------------------|
|  | Ex. 1        | Ex. 2 | Ex. 1             | Ex. 2 | Wood-sheathed Cruisers | Wood-sheathed Cruisers |            |                  |
| Mizen royal mast pole . . . = banded length              | .434         | —     | .190              | .800  | .085                   | .085                   | .186       | .208             |
| " sky-sail mast banded . . . = main sky-sail mast banded | —            | .090  | —                 | —     | —                      | —                      | —          | —                |
| " sky-sail mast pole . . . = banded length               | —            | .090  | —                 | —     | —                      | —                      | —          | —                |
| Main yard. Whole length . . . = length on water-line     | .853         | .358  | .278              | .284  | .291                   | .291                   | .238       | .268             |
| Yard arms, each . . . = yard                             | .037         | .036  | .041              | .044  | .042                   | .042                   | .050       | .056             |
| Fore yard. Whole length . . . = main yard                | 1.000        | 1.000 | 1.000             | 1.000 | 1.000                  | 1.000                  | 1.000      | 1.000            |
| Yard arms, each . . . = yard                             | .037         | .036  | .041              | .044  | .042                   | .042                   | .050       | .056             |
| Mizen yard. Whole length . . . = main yard               | .789         | .857  | .676              | .744  | .701                   | .701                   | .750       | .755             |
| Yard arms, each . . . = yard                             | .038         | .038  | .042              | .094  | .042                   | .042                   | .100       | .067             |
| Main lower topsail yard . . . = main yard                | .848         | .877  | —                 | —     | —                      | —                      | —          | —                |
| Yard arms, each . . . = yard                             | .024         | .052  | —                 | —     | —                      | —                      | —          | —                |
| Fore lower topsail yard . . . = main lower topsail yard  | 1.000        | 1.000 | —                 | —     | —                      | —                      | —          | —                |
| Yard arms, each . . . = yard                             | .024         | .052  | —                 | —     | —                      | —                      | —          | —                |
| Mizen lower topsail yard . . . = main lower topsail yard | .770         | .829  | —                 | —     | —                      | —                      | —          | —                |
| Yard arms, each . . . = yard                             | .026         | .053  | —                 | —     | —                      | —                      | —          | —                |
| Main upper topsail yard . . . = main yard                | .919*        | .933* | .705              | .744  | .750                   | .750                   | .800       | .762             |
| Yard arms, each . . . = yard                             | .052         | .032  | .081              | .094  | .085                   | .085                   | .078       | .082             |
| Fore upper topsail yard . . . = main upper topsail yard  | 1.000        | 1.000 | 1.000             | 1.000 | 1.000                  | 1.000                  | 1.000      | 1.000            |
| Yard arms, each . . . = yard                             | .052         | .032  | .081              | .094  | .085                   | .085                   | .078       | .082             |
| Mizen upper topsail yard . . . = main upper topsail yard | .808         | .794  | .696              | .672  | .729                   | .729                   | .687       | .738             |
| Yard arms, each . . . = yard                             | .088         | .040  | .082              | .061  | .088                   | .088                   | .079       | .100             |
| Main topgallant yard . . . = main upper topsail yard     | .816         | .816  | .622              | .672  | .678                   | .678                   | .641       | .672             |
| Yard arms, each . . . = yard                             | .049         | .039  | .048              | .061  | .042                   | .042                   | .061       | .061             |

\* Main lower topsail yard.

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS  
(concluded).

| SPECIES OF MASTS AND SPARS                         | Clipper Ships |       |       | Screw Vessels     |       |                        |            |                  |
|--|---------------|-------|-------|-------------------|-------|------------------------|------------|------------------|
|  | Ex. 1         |       | Ex. 2 | Ironclad Frigates |       | Wood-sheathed Corvette | Troop-ship | Merchant Steamer |
|  |               |       |       | Ex. 1             | Ex. 2 |                        |            |                  |
| Fore topgallant yard . . . = main topgallant yard  | .000          | 1.000 |       | 1.000             | 1.000 | 1.000                  | 1.000      | 1.000            |
| Yard arms, each . . . = yard                       | .049          | .039  |       | .043              | .061  | .042                   | .061       | .061             |
| Mizen topgallant yard . . . = main topgallant yard | .774          | .762  |       | .728              | .711  | .737                   | .732       | .561             |
| Yard arms, each . . . = yard                       | .035          | .040  |       | .042              | .039  | .044                   | .042       | .045             |
| Main royal yard . . . = main topgallant yard       | .818          | .742  |       | .706              | .667  | .787                   | .782       | .683             |
| Yard arms, each . . . = yard                       | .047          | .040  |       | .042              | .042  | .044                   | .042       | .045             |
| Fore royal yard . . . = main royal yard            | 1.000         | 1.000 |       | 1.000             | 1.000 | 1.000                  | 1.000      | 1.000            |
| Yard arms, each . . . = yard                       | .047          | .040  |       | .042              | .042  | .044                   | .042       | .045             |
| Mizen royal yard . . . = main royal yard           | .787          | .76   |       | .754              | .717  | .779                   | .733       | .500             |
| Yard arms, each . . . = yard                       | .045          | .034  |       | .042              | .046  | .040                   | .045       | .071             |
| Main skysail yard . . . = main royal yard          | —             | .773  |       | —                 | —     | —                      | —          | —                |
| Yard arms, each . . . = yard                       | —             | .034  |       | —                 | —     | —                      | —          | —                |
| Fore skysail yard . . . = main skysail yard        | —             | 1.000 |       | —                 | —     | —                      | —          | —                |
| Yard arms, each . . . = yard                       | —             | .034  |       | —                 | —     | —                      | —          | —                |
| Mizen skysail yard . . . = main skysail yard       | —             | .690  |       | —                 | —     | —                      | —          | —                |
| Yard arms, each . . . = yard                       | —             | .037  |       | —                 | —     | —                      | —          | —                |
| Spanker gaff. Whole length = spanker boom          | .677          | .785  |       | .700              | .700  | .670                   | .660       | .609             |
| boom. " = length of vessel                         | .216          | .216  |       | .184              | .199  | .197                   | .166       | .188             |
| Bowsprit, outside stem . . . = " " bowsprit        | .103          | .102  |       | .129              | .102  | .075                   | .099       | .112             |
| Jibboom, housing excluded . . . = " " jibboom      | 1.768         | 1.909 |       | 1.000             | 1.415 | 2.250                  | 1.813      | 2.015            |
| Housing " = " " jibboom                            | .527          | .524  |       | .337              | .348  | .466                   | .552       | .496             |
| Fore mast before after sternpost = " " water-line  | .771          | .779  |       | .575              | .774  | .826                   | .777       | .809             |
| Main " = " " "                                     | .452          | .463  |       | .425              | .430  | .441                   | .335       | .455             |
| Mizen " = " " "                                    | .190          | .174  |       | .161              | .164  | .161                   | .117       | .175             |



TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR BARQUES AND BRIGS.

| SPECIES OF MASTS AND SPARS   |   | Screw Steam Vessels              |       |                                 |       |                           |                              | Sailing Merchant Vessel. Barque-rigged |
|------------------------------|---|----------------------------------|-------|---------------------------------|-------|---------------------------|------------------------------|--|
|                              |   | Ironclad Frigates. Barque-rigged |       | Merchant Vessels. Barque-rigged |       | Troop-ship. Barque-rigged | Merchant Vessel. Brig-rigged |  |
|                              |   | Ex. 1                            | Ex. 2 | Ex. 1                           | Ex. 2 |                           |                              |  |
|                              |   |                                  |       |                                 |       |                           |                              |  |
| Main mast hounded            | . | 1.125                            | 1.126 | 1.410                           | 1.606 | 1.102                     | 1.395                        | 1.577                                  |
| " headed                     | . | .254                             | .317  | .264                            | .245  | .278                      | .264                         | .276                                   |
| " hounded                    | . | .913                             | .905  | .927                            | .898  | .908                      | .943                         | .928                                   |
| " headed                     | . | .278                             | .351  | .282                            | .272  | .286                      | .280                         | .298                                   |
| Mizen hounded                | . | .873                             | .873  | .837                            | .979  | 1.056                     | —                            | .928                                   |
| " headed                     | . | .230                             | .228  | .234                            | .167  | .175                      | —                            | .211                                   |
| Main topmast hounded.        | . | .687                             | .857  | 1.000                           | 1.000 | .820                      | 1.052                        | 1.267                                  |
| " headed                     | . | —                                | —     | .179                            | .167  | .184                      | .175                         | .167                                   |
| Fore hounded                 | . | 1.000                            | 1.000 | 1.000                           | 1.000 | 1.000                     | 1.000                        | 1.000                                  |
| " headed                     | . | —                                | —     | .179                            | .167  | .184                      | .175                         | .167                                   |
| Mizen hounded                | . | 1.247                            | 1.000 | .821                            | 1.567 | 1.093                     | —                            | 1.289                                  |
| " pole                       | . | .188                             | .188  | .344                            | .086  | .159                      | —                            | .207                                   |
| Main topgallant mast hounded | . | .393                             | .250  | .615                            | .623  | .459                      | .631                         | .690                                   |
| Fore pole                    | . | .114                             | .071  | .500                            | —     | —                         | .667                         | —                                      |
| " hounded                    | . | 1.000                            | 1.000 | 1.000                           | 1.000 | 1.000                     | 1.000                        | 1.000                                  |
| " pole                       | . | .114                             | .071  | .500                            | —     | —                         | .667                         | —                                      |
| Main royal mast hounded      | . | —                                | —     | —                               | .475  | .286                      | —                            | .408                                   |
| " pole                       | . | —                                | —     | —                               | .310  | .143                      | —                            | .138                                   |
| Fore hounded                 | . | —                                | —     | —                               | 1.000 | 1.000                     | —                            | 1.000                                  |
| " pole                       | . | —                                | —     | —                               | .310  | .143                      | —                            | .138                                   |
| Main yard.                   | . | .205                             | .325  | .224                            | .311  | .217                      | .260                         | .382                                   |
| Whole length                 | . | .067                             | .050  | .066                            | .043  | .044                      | .064                         | .047                                   |
| Yard arms, each              | . | 1.000                            | 1.000 | 1.000                           | 1.000 | 1.000                     | 1.000                        | 1.000                                  |
| Whole length                 | . | .067                             | .050  | .066                            | .043  | .044                      | .064                         | .047                                   |
| Yard arms, each              | . | 1.000                            | 1.000 | 1.000                           | 1.000 | 1.000                     | 1.000                        | 1.000                                  |
| Whole length                 | . | .067                             | .050  | .066                            | .043  | .044                      | .064                         | .047                                   |



TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS OF SCHOONERS AND BRIGS.

| SPECIES OF MASTS AND SPARS | Screw Steam Vessels |                               |                   |                          | Merchant Vessel, Brigs-rigged |       |
|----------------------------|---------------------|-------------------------------|-------------------|--------------------------|-------------------------------|-------|
|                            | Ironclads           | Sloop of War, Schooner rigged | Merchant Vessels  |                          |                               |       |
|                            |                     |                               | 3-masted Schooner | 3-masted Schooner rigged |                               |       |
| Fore mast hounded          | 1-125               | 1-127                         | 1-634             | 1-467                    | 1-950                         | 1-740 |
| " " headed                 | 222                 | 297                           | 235               | 230                      | 205                           | 218   |
| Main " hounded             | 1-089               | 1-125                         | 1-035             | 1-068                    | 1-051                         | 1-172 |
| Mizen " headed             | 204                 | 211                           | 230               | 213                      | 195                           | 186   |
| " " hounded                | 911                 | —                             | —                 | 848                      | —                             | —     |
| " " hounded                | 171                 | —                             | —                 | 173                      | —                             | —     |
| Fore topmast hounded       | 0-75                | 76                            | 807               | 850                      | 800                           | 1-868 |
| " " headed                 | —                   | —                             | —                 | —                        | —                             | 140   |
| Main " pole                | —                   | —                             | —                 | —                        | —                             | —     |
| " " hounded                | 1-426               | 1-870                         | 1-738             | 1-608                    | 1-75                          | 1-868 |
| " " pole                   | —                   | —                             | —                 | —                        | —                             | —     |
| Mizen " hounded            | 170                 | 135                           | 100               | 146                      | 143                           | 140   |
| " " hounded                | 148                 | —                             | —                 | 100                      | —                             | —     |
| " " pole                   | 151                 | —                             | —                 | 200                      | —                             | —     |
| Fore topg. mast hounded    | 340                 | 394                           | 481               | 588                      | 500                           | 600   |
| " " pole                   | 185                 | 111                           | 236               | 812                      | 400                           | —     |
| Main " hounded             | —                   | —                             | —                 | —                        | —                             | 1-067 |
| Fore royal " pole          | —                   | —                             | —                 | —                        | —                             | 867   |
| " " hounded                | —                   | —                             | —                 | —                        | —                             | 235   |
| Main " pole                | —                   | —                             | —                 | —                        | —                             | 1-117 |
| " " hounded                | —                   | —                             | —                 | —                        | —                             | 211   |
| Fore yard. Whole length.   | 800                 | 265                           | 400               | 810                      | 854                           | 450   |
| Yard arms, each            | 0-50                | 0-65                          | 0-50              | 0-60                     | 0-48                          | 0-48  |



| TABLE OF FACTORS USED TO DETERMINE THE DIAMETERS<br>OF SHIPS' MASTS AND SPARS. |                                    |                                    |  |
|--|------------------------------------|------------------------------------|--|
| SPECIES OF MASTS AND SPARS   |                                    | Given Diamr<br>= Whole<br>Length x | End Diameters<br>= Given Diameter<br>% |
| Lower masts  | Ships', brigs', and barques'.      | .026 to .028                       | heel . . .833                          |
|  |                                    |                                    | hounds . . .800                        |
|  | Cutters' . . . . .                 | .020 " .021                        | head . . .750                          |
|  |                                    |                                    | heel . . .833                          |
|  | Schooners' . . . . .               | .020 " .022                        | hounds . . .750                        |
|  |                                    |                                    | head . . .500                          |
|  | Luggers' . . . . .                 | .020 " .021                        | heel . . .833                          |
|  |                                    |                                    | hounds . . .800                        |
|  | Topmasts                           | .020 " .021                        | head . . .670                          |
|  |                                    |                                    | heel . . .938                          |
|  | Ships', brigs', and barques'.      | .020 " .021                        | hounds . . .750                        |
|  |                                    |                                    | head . . .583                          |
| Topmasts   | Ships', brigs', and barques'.      | .023 " .025                        | hounds . . .800                        |
|  |                                    |                                    | head . . .690                          |
|  | Cutters' and schooners'            | .020 " .022                        | hounds . . .771                        |
|  |                                    |                                    | head . . .500                          |
|  | Luggers' . . . . .                 | .020 " .021                        | hounds . . .771                        |
|  |                                    |                                    | pole . . .500                          |
|  | Topgallant masts . . . .           | .020 " .021                        | hounds . . .771                        |
|  |                                    |                                    | skysail pole .500                      |
|  | Ships', brigs', and barques'.      | .040 " .050                        | heel . . .833                          |
|  |                                    |                                    | head . . .666                          |
|  | Cutters' and schooners'            | .040 " .050                        | heel . . .1-000                        |
|  |                                    |                                    | head . . .666                          |
| Yards  | Lower yard . . . . .               | .020 " .025                        | yard arms* .500                        |
|  |                                    |                                    | heel . . .500                          |
|  | Topsail yard . . . . .             | .017 " .020                        | " . . .500                             |
|  |                                    |                                    | " . . .500                             |
|  | Topgallant and royal yard.         | .017 " .018                        | " . . .500                             |
|  |                                    |                                    | " . . .500                             |
|  | Cross jack yard . . . .            | .020 " .025                        | " . . .500                             |
|  |                                    |                                    | " . . .500                             |
|  | Cutters' and schooners' squaresail | .014 " .017                        | " . . .500                             |
|  |                                    |                                    | " . . .500                             |
|  | Cutters' and schooners' topsail    | .017 " .020                        | " . . .500                             |
|  |                                    |                                    | " . . .500                             |
| Booms  | Luggers' yards . . . . .           | .018 " .023                        | " . . .500                             |
|  |                                    |                                    | " . . .500                             |
|  | Driver boom . . . . .              | .017 " .020                        | outer end . . .75                      |
|  |                                    |                                    | inner " . . .66                        |
|  | Main and cutters' booms . .        | .017 " .020                        | outer " . . .75                        |
|  |                                    |                                    | inner " . . .71                        |
|  | Jibboom . . . . .                  | .020 " .025                        | outer " . . .75                        |
|  |                                    |                                    | inner " . . .1-00                      |
|  | Flying jibboom . . . . .           | .017 " .020                        | outer " . . .66                        |
|  |                                    |                                    | inner " . . .75                        |
|  | Jib and flying jibboom in one      | .022 " .026                        | outer " . . .66                        |
|  |                                    |                                    | inner " . . .50                        |
| Gaffs  | Ships' and brigs' . . . .          | .018 " .022                        | outer end . . .50                      |
|  |                                    |                                    | " . . .60                              |
|  | Cutters' and schooners' . .        | .018 " .022                        | " . . .60                              |
|  | Trysail gaffs . . . . .            | .030 " .040                        | " . . .60                              |

*Note.*—The factors in the above table will apply equally well whether the masts and spars are of wood or of iron.

TABLE OF POSITION AND RAKE OF MASTS FOR SAILING VESSELS.

| RIG AND NAMES OF MASTS |  | Distance from Middle of Water Line in Fractions of the Length of that Line |                                   | Rake in Twelve Feet   |
|------------------------|--|--|-----------------------------------|---|
|                        |  | Before   | Abaft                             | Inches  |
| Frigate                | { main mast .<br>fore „ .<br>mizen „ . | —<br>.37 to .39<br>—   | .062 to .069<br>—<br>.341 to .404 | 6 to 5<br>2 to 1<br>10 to 9   |
| Corvette               | { main „ .<br>fore „ .<br>mizen „ .    | —<br>.372 to .399<br>—   | .096 to .06<br>—<br>.375 to .356  | 6 to 10 $\frac{1}{2}$<br>2 to 1 $\frac{3}{4}$<br>10 to 10 $\frac{3}{4}$ |
| Clipper ship           | { main „ .<br>fore „ .<br>mizen „ .    | —<br>.274<br>—   | .047<br>—<br>.309                 | 1<br>9<br>15  |
| Lugger                 | { main „ .<br>fore „ .<br>mizen „ .    | —<br>.396<br>—   | .04<br>—<br>.396                  | .12<br>.6<br>.24  |
| Barque                 | { main „ .<br>fore „ .<br>mizen „ .    | —<br>.300<br>—   | .067<br>—<br>.349                 | 13<br>11<br>17  |
| 3-masted schooner      | { main „ .<br>fore „ .<br>mizen „ .    | —<br>.295<br>—   | .033<br>—<br>.366                 | 27<br>24<br>30  |
| Common schooner        | { main „ .<br>fore „ .                 | —<br>.338  | .046<br>—                         | 24<br>15  |
| Bermuda schooner       | { main „ .<br>fore „ .                 | —<br>.279 to .31   | .108 to .084<br>—                 | 24 to 33<br>16 to 36  |
| Brig of war            | { main „ .<br>fore „ .                 | —<br>.331 to .323  | .147 to .138<br>—                 | 10 to 9<br>3 to 2   |
| Yacht as brig          | { main „ .<br>fore „ .                 | —<br>.323  | .144<br>—                         | 10<br>2 $\frac{1}{2}$   |
| Ketch                  | { main „ .<br>mizen „ .                | .11<br>—   | —<br>.395                         | 12<br>18  |
| Revenue cutter         | { main „ .                             | .13 to .104  | —                                 | 14 to 13  |
| Cutter yacht           | main „ .                               | .112 to .14  | —                                 | 12 to 15  |

# 350 WEIGHT OF MASTS, SPARS, RIGGING, CABLES, ETC.

TABLE OF THE WEIGHT OF VESSELS, MASTS, SPARS, RIGGING, AND SAILS IN TONS.

| Kind of Vessel            | Sailing Ships |       |       |       |       |
|---------------------------|---------------|-------|-------|-------|-------|
| Tonnage (B.M.)            | 2,600         | 2,200 | 1,700 | 1,400 | 1,000 |
| Lower masts and bowsprit* | 32.6          | 31.9  | 26.7  | 24.1  | 21.4  |
| Topmasts and yards        | 27.1          | 26.0  | 27.5  | 26.5  | 18.6  |
| Spare gear and booms      | 16.5          | 16.0  | 12.6  | 12.0  | 7.3   |
| Standing rigging†         | 22.0          | 21.2  | 20.2  | 19.1  | 11.0  |
| Running                   | 18.1          | 17.2  | 16.9  | 16.3  | 11.4  |
| Blocks to                 | 12.9          | 11.1  | 10.6  | 10.0  | 6.4   |
| Ship's sails              | 6.9           | 7.3   | 6.0   | 6.1   | 3.8   |
| Spare                     | 4.2           | 4.4   | 3.7   | 3.4   | 2.3   |

| Kind of Vessel           | Sailing Ship | Brigs |     | Schooner | Cutter |
|--------------------------|--------------|-------|-----|----------|--------|
| Tonnage (B.M.)           | 500          | 280   | 280 | 180      | 160    |
| Lower masts and bowsprit | 4.1          | 7.5   | 4.2 | 6.4      | 6.5    |
| Topmasts and yards       | 8.8          | 7.2   | 5.3 | 1.9      | 2.6    |
| Spare gear and booms     | 4.1          | 3.0   | 2.2 | 1.2      | —      |
| Standing rigging†        | 8.4          | 3.3   | 2.4 | 1.0      | 1.7    |
| Running                  | 6.5          | 4.5   | 2.8 | 1.4      | 1.3    |
| Blocks to                | 4.3          | 2.0   | 1.6 | .8       | .7     |
| Ship's sails             | 2.1          | 1.5   | 1.2 | 1.3      | 1.6    |
| Spare                    | 1.5          | 1.2   | .85 | .8       | .25    |

\* The masts and spars are all of wood.

† Standing rigging of wire.

TABLE OF THE RELATIVE PROPORTIONS OF IRON AND HEMPEN CABLES, TOGETHER WITH THEIR WEIGHT.

| Diam.<br>of Chain |       | Girth<br>of Hemp |     | Weight of 100 Fathoms |      |      |     | Diam.<br>of Chain |       | Girth<br>of Hemp |     | Weight of 100 Fathoms |      |      |     |
|-------------------|-------|------------------|-----|-----------------------|------|------|-----|-------------------|-------|------------------|-----|-----------------------|------|------|-----|
|                   |       |                  |     | Chain                 |      | Hemp |     |                   |       |                  |     | Chain                 |      | Hemp |     |
| Inch.             | Inch. | Cwt.             | Qr. | Lb.                   | Cwt. | Qr.  | Lb. | Inch.             | Inch. | Cwt.             | Qr. | Lb.                   | Cwt. | Qr.  | Lb. |
| 4                 | 7½    | 29               | 3   | 17                    | 10   | 2    | 9   | 1½                | 15    | 110              | 0   | 14                    | 43   | 0    | 1   |
|                   | 12    |                  |     |                       | 0    | 26   | 15½ |                   | 45    |                  |     |                       | 3    | 27   |     |
|                   | 13    |                  |     |                       | 3    | 16   | 16  |                   | 48    |                  |     |                       | 3    | 24   |     |
| 5                 | 9     | 39               | 1   | 21                    | 15   | 2    | 95  | 1½                | 16½   | 126              | 2   | 10                    | 51   | 3    | 2   |
|                   | 17    |                  |     |                       | 0    | 22   | 17  |                   | 55    |                  |     |                       | 1    | 0    |     |
|                   | 18    |                  |     |                       | 0    | 21   | 17½ |                   | 58    |                  |     |                       | 2    | 6    |     |
| 1                 | 10    | 50               | 0   | 14                    | 21   | 0    | 20  | 1½                | 18    | 155              | 0   | 9                     | 61   | 3    | 12  |
|                   | 23    |                  |     |                       | 1    | 0    | 18½ |                   | 65    |                  |     |                       | 2    | 10   |     |
|                   | 25    |                  |     |                       | 0    | 15   | 19  |                   | 69    |                  |     |                       | 0    | 17   |     |
| 1½                | 11    | 66               | 3   | 5                     | 27   | 1    | 23  | 1½                | 20    | 180              | 3   | 14                    | 76   | 3    | 1   |
|                   | 29    |                  |     |                       | 8    | 3    | 21  |                   | 84    |                  |     |                       | 1    | 14   |     |
|                   | 32    |                  |     |                       | 1    | 19   | 22  |                   | 92    |                  |     |                       | 3    | 16   |     |
| 1½                | 13    | 81               | 3   | 12                    | 35   | 0    | 7   | 2                 | 23    | 190              | 0   | 14                    | 101  | 2    | 8   |
|                   | 37    |                  |     |                       | 2    | 4    | 24  |                   | 110   |                  |     |                       | 2    | 1    |     |
|                   | 40    |                  |     |                       | 1    | 12   | 25  |                   | 119   |                  |     |                       | 3    | 2    |     |

TABLE GIVING THE GIRTHS OF HEMP AND WIRE ROPE OF EQUIVALENT STRENGTHS.

| Hemp<br>(ins.) | Wire<br>(ins.) | Hemp<br>(ins.) | Wire<br>(ins.) | Hemp<br>(ins.) | Wire<br>(ins.) | Hemp<br>(ins.) | Wire<br>(ins.) | Hemp<br>(ins.) | Wire<br>(ins.) | Hemp<br>(ins.) | Wire<br>(ins.) |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 12             | 4½             | 10½            | 4½             | 8½             | 3½             | 6½             | 2½             | 5              | 2              | 3½             | 1½             |
| 11½            | —              | 10             | 4              | 8½             | 3½             | 6½             | 2½             | 4½             | —              | 3              | 1½             |
| 11½            | 4½             | 9½             | —              | 8              | 3½             | 6½             | 2½             | 4½             | 1½             | 2½             | 1½             |
| 11½            | —              | 9½             | 3½             | 7½             | 3½             | 6              | 2½             | 4½             | —              | 2½             | 1              |
| 11             | 4½             | 9½             | —              | 7½             | 3½             | 5½             | 2½             | 4              | 1½             | 2½             | —              |
| 10½            | —              | 9              | 3½             | 7½             | 3              | 5½             | 2½             | 3½             | 1½             | 2              | —              |
| 10½            | 4½             | 8½             | —              | 7              | 2½             | 5½             | —              | 3½             | 1½             | 1½             | —              |

TABLE SHOWING FROM WHAT NUMBERS OF CANVAS THE DIFFERENT SAILS ARE MADE.

| No. of<br>Canvas | Species of Sails made of the given Number of Canvas   |
|------------------|---|
| 0                | Courses, lower staysails, trysails.   |
| 1                | Courses, lower staysails, trysails, awnings.  |
| 2                | Courses, topsails, lower staysails, trysails, spankers, awnings.  |
| 3                | Courses, topsails, spankers, jibs, lower and topmast staysails.   |
| 4                | Topsails, topgallant sails, spankers, jibs, topmast staysails.  |
| 5                | { Topsails, lower and topmast studding sails, spankers, jibs,<br>upper staysails, gaff topsails.  |
| 6                | { Topgallant sails, studding sails, jibs, flying jibs, upper stay-<br>sails, gaff topsails, cutters' and schooners' crossjack sails<br>and square topsails, sails of boats. |
| 7                | { Topgallant sails, studding sails, flying jibs, royal staysails,<br>cutters' and schooners' topsails, sails of boats.  |
| 8                | { Royals, skysails, topgallant and royal studding sails, cutters'<br>and schooners' topgallant sails, sails of boats.   |

*Note.*—For the weight of the several numbers of canvas see p. 303.

#### WEIGHT OF SHIPS' RIGGING AND BLOCKS.

|  |                         |
|--|-------------------------|
| Weight of a ship's running rigging = weight of | { sailing ships . 1.584 |
| wire standing rigging × . . . . .              | { barques . 1.682       |
|  | { brigs . 1.719         |
| Weight of a ship's blocks = weight of running  | { sailing ships . .369  |
| rigging × . . . . .                            | { barques . .302        |
|  | { brigs . .254          |

*Note.*—The above constants must only be taken as rough approximations.

#### PROPORTIONS OF TRESTLE AND CROSS TREES IN SHIPS' TOPS.

|                         |                                      |
|-------------------------|--------------------------------------|
| Length of trestle-trees | = hounded length of topmast × .22    |
| Breadth of ditto        | = length . . . . . × .11             |
| Depth of ditto          | = breadth . . . . . × .67            |
| Length of cross-trees   | = hounded length of topmast × .81    |
| Breadth of ditto        | = breadth of trestle-trees . . × 1.0 |
| Depth of ditto          | = breadth . . . . . × .67            |
| Length of lubber's hole | = length of trestle-trees . . × .41  |
| Length of sd            | = diameter of lower-mast . . × 1.50  |





TABLE SHOWING THE SIZES AND TOTAL WEIGHTS OF THE STANDING RIGGING OF STEAM SHIPS WHEN MADE OF MESSRS. R. S. NEWALL AND CO.'S PATENT IMPROVED WIRE ROPE, COMPARED WITH RIGGING MADE OF THE BEST HEMP ROPE.

|                           | 3,000 Tons   | 2,500 Tons   | 2,000 Tons   | 1,500 Tons   | 1,000 Tons   | 800 Tons     | 600 Tons     | 400 Tons     | 200 Tons     | 100 Tons     |
|---------------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|                           | Girth (ins.) | Girth (ins.) | Girth (ins.) | Girth (ins.) | Girth (ins.) | Girth (ins.) | Girth (ins.) | Girth (ins.) | Girth (ins.) | Girth (ins.) |
|                           | Hemp Wire    | Hemp Wire    | Hemp Wire    | Hemp Wire    | Hemp Wire    | Hemp Wire    | Hemp Wire    | Hemp Wire    | Hemp Wire    | Hemp Wire    |
|                           | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  | Wt. Qr. Lb.  |
| Fore & main shrouds       | 10 1/2       | 10 1/2       | 10 1/2       | 10 1/2       | 10 1/2       | 10 1/2       | 10 1/2       | 10 1/2       | 10 1/2       | 10 1/2       |
| Mizen shrouds             | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        |
| Fore & main stays (dbl.)  | 12 1/2       | 12 1/2       | 12 1/2       | 12 1/2       | 12 1/2       | 12 1/2       | 12 1/2       | 12 1/2       | 12 1/2       | 12 1/2       |
| Mizen stay (single)       | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        | 7 1/2        |
| Fore & main shrouds       | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Mizen shrouds             | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Fore & main stays (dbl.)  | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        |
| Mizen stay (single)       | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        | 9 1/2        |
| Fore & main backstays     | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        |
| Mizen backstays           | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        | 6 1/2        |
| Fore & main shrouds       | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Mizen shrouds             | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Fore & main stays         | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Mizen stays               | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Fore & main backstays     | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Mizen backstays           | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Fore & main stays         | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Mizen stay                | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Fore & main backstays     | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Mizen backstays           | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Standing jib stay         | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Flying                    | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Standing guys             | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Flying                    | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Martingale stay           | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Martingale back-ropes     | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Bob- (3 of wire, single)  | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Stays (3 of hemp, double) | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Fore & main shrouds       | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        | 4 1/2        |
| Wt. of rigging            | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     |
| Wt. of wire               | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     | 147 0 30     |

Wire rigging is now almost universally used for the standing rigging of ships, as its advantages over that of hemp are considerable, the weight being about one-half that of hemp, while the weight is reduced to nearly one-half; it does not stretch permanently under great strain, as hemp rigging does, and it is liable to those sudden alterations of length to which hemp is subject by change in the state of moisture of the atmosphere, and which give rise to the inconvenience and great labour in setting up the rigging.



TABLE SHOWING THE SIZE AND TOTAL WEIGHTS OF THE STANDING RIGGING OF STEAM SHIPS WHEN MADE OF MESSRS. R. S. NEWALL AND CO.'S PATENT IMPROVED WIRE ROPE, COMPARED WITH RIGGING MADE OF THE BEST HEMP ROPE.

| SPICES OF STANDING RIGGING | 3,000 Tons | 2,500 Tons | 2,000 Tons | 1,800 Tons | 1,500 Tons | 1,000 Tons | 850 Tons  | 600 Tons  | 550 Tons  | 300 Tons  |
|----------------------------|------------|------------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|
|                            | Hemp Wire  | Hemp Wire  | Hemp Wire  | Hemp Wire  | Hemp Wire  | Hemp Wire  | Hemp Wire | Hemp Wire | Hemp Wire | Hemp Wire |
| Fore & main shrouds        | 44         | 41         | 10         | 44         | 4          | 4          | 5         | 34        | 34        | 4         |
| Main shrouds               | 7          | 7          | 64         | 3          | 4          | 24         | 5         | 54        | 44        | 4         |
| Foremast stays (dbl.)      | 12         | 13         | 13         | 44         | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen stay (single)        | 74         | 4          | 74         | 24         | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main shrouds        | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen shrouds              | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main stays (dbl.)   | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen stay (single)        | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main backstays      | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen backstays            | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main shrouds        | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen shrouds              | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main stays          | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen stays                | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main backstays      | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen backstays            | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main stays          | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen stay                 | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Fore & main backstays      | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Mizen backstays            | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Standing jib stay          | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Flying                     | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Standing guys              | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Flying                     | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Martingale stay            | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Martingale back-ropes      | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Bob- (3 of wire, single)   | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| stays (3 of hemp, double)  | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Flowerpuffs shrouds        | 4          | 4          | 4          | 4          | 4          | 4          | 4         | 4         | 4         | 4         |
| Total wt. of hemp rigging  | 147        | 147        | 147        | 147        | 147        | 147        | 147       | 147       | 147       | 147       |
| wire                       | 147        | 147        | 147        | 147        | 147        | 147        | 147       | 147       | 147       | 147       |

Wire rigging is now almost universally used for the standing rigging of ships, as its advantages over that of hemp are considerable, its bulk being about one-fourth that of hemp, while the weight is reduced to nearly one-half; it does not stretch permanently under great strains, as hemp rigging does, and it is liable to those sudden alterations of length to which hemp is subject by change in the state of moisture of the atmosphere, and which give rise to great inconvenience and great labour in setting up the rigging.

# 354 PROPORTIONS OF RIGGING TO THE MASTS AND SPARS.

TABLE FOR SAILING SHIPS, SHOWING THE PROPORTIONS WHICH THE DIAMETER OF CHAIN RIGGING AND THE GIRTHS OF HEMP OR WIRE RIGGING SHOULD BEAR TO THE DIAMETERS OF THE MASTS, YARDS, &c., FROM WHICH THE RIGGING LEADS.\*

| PARTS OF RIGGING               |                      | Ratio | PARTS OF RIGGING                     |                         | Ratio |
|--------------------------------|----------------------|-------|--------------------------------------|-------------------------|-------|
| Fore and main<br>masts         | Pendants             | 375   | Fore and main<br>yards               | Braces                  | 250   |
|                                | Shrouds †            | 168   |                                      | Lifts                   | 291   |
|                                | Stays †              | 227   |                                      | Parrel rope             | 333   |
|                                | Ratlines             | 057   |                                      | Clewlines               | 291   |
|                                | Foot-ropes           | 281   |                                      | Buntlines               | 250   |
|                                | Stirrups             | 187   |                                      | Bowlines                | 250   |
|                                | Lifts                | 250   |                                      | Reef tackles            | 250   |
|                                | Braces               | 250   |                                      | Sheets †                | 050   |
|                                | Tacks                | 312   |                                      | Studding-sail halliards | 291   |
|                                | Sheets               | 312   |                                      | Sheets                  | 272   |
| Fore and main<br>yards         | Clew garnets         | 218   | Fore and main<br>topgallant<br>masts | Tacks                   | 291   |
|                                | Bowlines             | 250   |                                      | Downhaul                | 167   |
|                                | Bridles              | 250   |                                      | Room jiggers            | 167   |
|                                | Buntlines            | 187   |                                      | Heel lashing            | 250   |
|                                | Leechlines           | 156   |                                      | Boom-brace pendant      | 291   |
|                                | Stabline             | 125   |                                      | Whip                    | 167   |
|                                | Fore staysail stay † | 149   |                                      | Shrouds †               | 194   |
|                                | Halliards            | 187   |                                      | Backstays †             | 208   |
|                                | Sheets               | 187   |                                      | Stay †                  | 194   |
|                                | Tack lashing         | 125   |                                      | Royal stay †            | 111   |
| Fore and main<br>topmasts      | Downhaul             | 156   |                                      | Backstay †              | 111   |
|                                | Lower studding sail  | —     | Fore and main<br>royal<br>yards      | Halliards and strapping | 438   |
|                                | Halliards            | 187   |                                      | Foot-ropes              | 313   |
|                                | Inner halliards      | 187   |                                      | Braces and strapping    | 281   |
|                                | Sheets and tack      | 187   |                                      | Lifts                   | 375   |
|                                | Shrouds †            | 168   |                                      | Parrel ropes            | 250   |
|                                | Ratlines             | 065   |                                      | Clewlines               | 250   |
|                                | Backstays            | 186   |                                      | Bowlines                | 250   |
|                                | Burton pendants      | 290   |                                      | Bridles                 | 250   |
|                                | Stays †              | 186   |                                      | Sheets                  | 470   |
|                                | Futtock shrouds      | 153   |                                      | Studding-sail halliards | 313   |
| Fore and main<br>sail<br>yards | Ratlines             | 065   |                                      | Sheets                  | 250   |
|                                | Staysail halliards   | 193   |                                      | Tacks                   | 250   |
|                                | Downhaul             | 161   |                                      | Downhaul                | 188   |
|                                | Pendants             | 290   |                                      | Halliards               | 417   |
|                                | Sheets               | 224   |                                      | Foot-ropes              | 167   |
|                                | Top-sail ties †      | 050   |                                      | Braces and strapping    | 333   |
|                                | Halliards            | 250   |                                      | Lifts                   | 333   |
|                                | Foot-ropes           | 291   |                                      | Parrel lashing          | 167   |
|                                | Stirrups             | 167   |                                      | Clewlines & bowlines    | 167   |
|                                | Flemish horses       | 208   |                                      | Sheets                  | 375   |

\* All the rigging is of hemp, except that marked otherwise.  
† Wire-rope rigging.

‡ Chain rigging.

TABLE FOR SAILING SHIPS, SHOWING THE PROPORTIONS OF CHAIN AND HEMP AND WIRE-ROPE RIGGING IN RELATION TO THE MASTS AND SPARS (concluded).\*

| PARTS OF RIGGING    |                                  | Ratio | PARTS OF RIGGING |                         | Ratio |
|---------------------|----------------------------------|-------|------------------|-------------------------|-------|
| Mizen mast          | Shrouds †                        | ·146  | Mizen royal yard | Foot-ropes              | ·200  |
|                     | Burton pendants                  | ·250  |                  | Braces and strapping    | ·200  |
|                     | Ratlines                         | ·069  |                  | Parrel lashing          | ·100  |
|                     | Stay †                           | ·174  |                  | Lifts                   | ·300  |
|                     | Seizings †                       | ·027  |                  | Halliards               | ·400  |
|                     | Foot-ropes                       | ·231  |                  | Sheets                  | ·200  |
|                     | Stirrups                         | ·200  |                  | Clewlines               | ·200  |
|                     | Lifts                            | ·200  |                  | Topping lifts           | ·450  |
|                     | Braces & strapping               | ·200  |                  | Falls and strapping     | ·300  |
|                     |                                  |       |                  | Boom sheet              | ·350  |
| Cross-jack yard     | Shrouds †                        | ·167  | Spanker boom     | Outhaul                 | ·350  |
|                     | Stay †                           | ·167  |                  | Guy pendants            | ·350  |
|                     | Ratlines                         | ·056  |                  | Falls                   | ·250  |
|                     | Backstays †                      | ·156  |                  | Strapping to do         | ·250  |
|                     | Furtock shrouds †                | ·156  |                  | Throat halliards        | ·400  |
|                     | Top-sail ties †                  | ·050  |                  | Peak halliards          | ·400  |
|                     | Halliards for do.                | ·274  |                  | Vang pendants           | ·450  |
|                     | Foot-ropes                       | ·211  |                  | Falls and strapping     | ·200  |
|                     | Stirrups                         | ·274  |                  | Peak brails             | ·200  |
|                     | Flemish horses                   | ·211  |                  | Throat brails           | ·250  |
| Mizen topmast       | Parrel rope                      | ·316  | Gaff             | Middle brails           | ·200  |
|                     | Lifts                            | ·316  |                  | Hook brails             | ·200  |
|                     | Braces                           | ·274  |                  | Gammeling †             | ·028  |
|                     | Sheets †                         | ·050  |                  | Shrouds †               | ·028  |
|                     | Clewlines                        | ·211  |                  | Bobstays †              | ·038  |
|                     | Buntlines                        | ·211  |                  | Man-ropes               | ·150  |
|                     | Span                             | ·211  |                  | Jibstay †               | ·152  |
|                     | Bowlines                         | ·211  |                  | Guy, single †           | ·143  |
|                     | Bridles                          | ·211  |                  | Foot-ropes              | ·214  |
|                     | Reef tackles                     | ·237  |                  | Martingale stay †       | ·205  |
| Mizen top-sail yard | Shrouds †                        | ·179  | Jibboom          | Martingale backropes †  | ·134  |
|                     | Backstays †                      | ·179  |                  | Halliards               | ·232  |
|                     | Stay †                           | ·179  |                  | Downhaul                | ·214  |
|                     | Royal stay †                     | ·144  |                  | Sheets                  | ·178  |
|                     | Backstays †                      | ·144  |                  | Pendants                | ·321  |
|                     | Foot-ropes                       | ·231  |                  | Flying jib stay †       | ·150  |
|                     | Parrel lashing                   | ·231  |                  | Guy †                   | ·125  |
|                     | Lifts                            | ·308  |                  | Foot-ropes              | ·250  |
|                     | Halliards                        | ·346  |                  | Martingale stay †       | ·175  |
|                     | Sheets                           | ·308  |                  | Halliards and strapping | ·250  |
| Mizen topgallant    | Clewlines                        | ·231  | Flying jibboom   | Downhaul and strapping  | ·200  |
|                     | Bowlines                         | ·231  |                  | Sheets                  | ·250  |
|                     | Bridles                          | ·231  |                  | Heel lashing            | ·150  |
|                     | Strapping, $\frac{1}{2}$ -blocks | ·308  |                  |                         |       |
|                     |                                  |       |                  |                         |       |
|                     |                                  |       |                  |                         |       |
|                     |                                  |       |                  |                         |       |
|                     |                                  |       |                  |                         |       |
|                     |                                  |       |                  |                         |       |
|                     |                                  |       |                  |                         |       |

\* All the rigging is of hemp, except that marked otherwise.

† Wire-rope rigging.

‡ Chain rigging.

Note.—Girth of any lanyard=girth of rope set up by  $\frac{1}{2} \times \frac{1}{2}$ .

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches).

| Length of Block                   | Breadth of Block | Thickness of Block | Length of Mortise | Diameter of Sheave | Thickness of Sheave | Size of Pin hole | Length of Block | Breadth of Block | Thickness of Block | Length of Mortise | Diameter of Sheave | Thickness of Sheave | Size of Pin hole |
|-----------------------------------|------------------|--------------------|-------------------|--------------------|---------------------|------------------|-----------------|------------------|--------------------|-------------------|--------------------|---------------------|------------------|
| <i>Common Single-thick Blocks</i> |                  |                    |                   |                    |                     |                  |                 |                  |                    |                   |                    |                     |                  |
| 3                                 | 2 $\frac{1}{2}$  | 1 $\frac{1}{2}$    | 2 $\frac{1}{2}$   | 1 $\frac{1}{2}$    | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 17              | 12 $\frac{1}{2}$ | 7 $\frac{1}{2}$    | 13                | 10 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 4                                 | 3 $\frac{1}{2}$  | 2                  | 3 $\frac{1}{2}$   | 2 $\frac{1}{2}$    | 2 $\frac{1}{2}$     | 2 $\frac{1}{2}$  | 18              | 13 $\frac{1}{2}$ | 7 $\frac{1}{2}$    | 13                | 11 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 5                                 | 4                | 2 $\frac{1}{2}$    | 3 $\frac{1}{2}$   | 3 $\frac{1}{2}$    | 3 $\frac{1}{2}$     | 3 $\frac{1}{2}$  | 19              | 14 $\frac{1}{2}$ | 8                  | 14                | 12                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 6                                 | 4 $\frac{1}{2}$  | 2 $\frac{3}{4}$    | 4                 | 3 $\frac{3}{4}$    | 4 $\frac{1}{2}$     | 4 $\frac{1}{2}$  | 20              | 14 $\frac{1}{2}$ | 8 $\frac{1}{2}$    | 15                | 12 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 7                                 | 5 $\frac{1}{2}$  | 3 $\frac{1}{4}$    | 5                 | 4 $\frac{1}{4}$    | 5 $\frac{1}{2}$     | 5 $\frac{1}{2}$  | 21              | 15 $\frac{1}{2}$ | 9                  | 15 $\frac{1}{2}$  | 13                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 8                                 | 6 $\frac{1}{2}$  | 3 $\frac{1}{2}$    | 6                 | 5                  | 6 $\frac{1}{2}$     | 6 $\frac{1}{2}$  | 22              | 16 $\frac{1}{2}$ | 9 $\frac{1}{2}$    | 16                | 14                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 9                                 | 7                | 4 $\frac{1}{4}$    | 7 $\frac{1}{4}$   | 5 $\frac{3}{4}$    | 7 $\frac{1}{2}$     | 7 $\frac{1}{2}$  | 23              | 16 $\frac{1}{2}$ | 9 $\frac{1}{2}$    | 17                | 14 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 10                                | 7 $\frac{1}{2}$  | 4 $\frac{1}{2}$    | 7 $\frac{1}{2}$   | 6 $\frac{1}{2}$    | 8 $\frac{1}{2}$     | 8 $\frac{1}{2}$  | 24              | 17 $\frac{1}{2}$ | 10                 | 18                | 18                 | 3                   | 1 $\frac{1}{2}$  |
| 11                                | 8 $\frac{1}{2}$  | 5                  | 8 $\frac{1}{2}$   | 7                  | 9 $\frac{1}{2}$     | 9 $\frac{1}{2}$  | 25              | 17 $\frac{1}{2}$ | 10 $\frac{1}{2}$   | 19                | 15 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 12                                | 9 $\frac{1}{2}$  | 5 $\frac{1}{2}$    | 9 $\frac{1}{2}$   | 7 $\frac{3}{4}$    | 10 $\frac{1}{2}$    | 10 $\frac{1}{2}$ | 26              | 18 $\frac{1}{2}$ | 10 $\frac{1}{2}$   | 19 $\frac{1}{2}$  | 16 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 13                                | 10 $\frac{1}{2}$ | 5 $\frac{3}{4}$    | 10                | 8 $\frac{1}{4}$    | 11 $\frac{1}{2}$    | 11 $\frac{1}{2}$ | 27              | 19               | 11                 | 20                | 17                 | 3 $\frac{1}{2}$     | 2                |
| 14                                | 10 $\frac{1}{2}$ | 6                  | 10 $\frac{1}{2}$  | 9                  | 12 $\frac{1}{2}$    | 12 $\frac{1}{2}$ | 28              | 19 $\frac{1}{2}$ | 11 $\frac{1}{2}$   | 21                | 17 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 2                |
| 15                                | 11 $\frac{1}{2}$ | 6 $\frac{1}{4}$    | 11 $\frac{1}{2}$  | 9 $\frac{1}{2}$    | 13 $\frac{1}{2}$    | 13 $\frac{1}{2}$ | 29              | 20 $\frac{1}{2}$ | 11 $\frac{1}{2}$   | 22                | 18 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 2                |
| 16                                | 12 $\frac{1}{2}$ | 7                  | 12 $\frac{1}{2}$  | 10                 | 14 $\frac{1}{2}$    | 14 $\frac{1}{2}$ | 30              | 21               | 12                 | 22 $\frac{1}{2}$  | 18 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 2                |
| <i>Common Single-thin Blocks.</i> |                  |                    |                   |                    |                     |                  |                 |                  |                    |                   |                    |                     |                  |
| 8                                 | 6 $\frac{1}{2}$  | 3 $\frac{1}{2}$    | 6 $\frac{1}{2}$   | 5 $\frac{1}{2}$    | 7                   | 7                | 19              | 15               | 6 $\frac{1}{2}$    | 15                | 13 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 9                                 | 7 $\frac{1}{2}$  | 3 $\frac{3}{4}$    | 7 $\frac{1}{2}$   | 6                  | 8                   | 8                | 20              | 15 $\frac{1}{2}$ | 6 $\frac{3}{4}$    | 16                | 14                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 10                                | 8 $\frac{1}{2}$  | 4 $\frac{1}{4}$    | 8                 | 6 $\frac{3}{4}$    | 9                   | 9                | 21              | 16 $\frac{1}{2}$ | 6 $\frac{3}{4}$    | 16 $\frac{1}{2}$  | 14 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 11                                | 9                | 4 $\frac{1}{2}$    | 8 $\frac{1}{2}$   | 7 $\frac{1}{2}$    | 10                  | 10               | 22              | 17 $\frac{1}{2}$ | 6 $\frac{3}{4}$    | 17                | 15                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 12                                | 9 $\frac{1}{2}$  | 4 $\frac{3}{4}$    | 9                 | 8 $\frac{1}{4}$    | 11                  | 11               | 23              | 18               | 6 $\frac{3}{4}$    | 17 $\frac{1}{2}$  | 15 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 13                                | 10 $\frac{1}{2}$ | 5                  | 10 $\frac{1}{2}$  | 9                  | 12                  | 12               | 24              | 18 $\frac{1}{2}$ | 6 $\frac{3}{4}$    | 18 $\frac{1}{2}$  | 16 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 14                                | 11 $\frac{1}{2}$ | 5 $\frac{1}{4}$    | 11 $\frac{1}{2}$  | 9 $\frac{1}{4}$    | 13                  | 13               | 25              | 19 $\frac{1}{2}$ | 7                  | 19 $\frac{1}{2}$  | 17                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 15                                | 12               | 5 $\frac{1}{2}$    | 12                | 10 $\frac{1}{2}$   | 14                  | 14               | 26              | 20 $\frac{1}{2}$ | 7                  | 20 $\frac{1}{2}$  | 18                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 16                                | 12 $\frac{1}{2}$ | 5 $\frac{3}{4}$    | 12 $\frac{1}{2}$  | 11 $\frac{1}{4}$   | 15                  | 15               | 27              | 21               | 7                  | 31                | 19                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 17                                | 13 $\frac{1}{2}$ | 6                  | 13 $\frac{1}{2}$  | 12                 | 16                  | 16               | 28              | 21 $\frac{1}{2}$ | 7                  | 22 $\frac{1}{2}$  | 20                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 18                                | 14 $\frac{1}{2}$ | 6 $\frac{1}{4}$    | 14 $\frac{1}{2}$  | 12 $\frac{1}{2}$   | 17                  | 17               | —               | —                | —                  | —                 | —                  | —                   | —                |
| <i>Clump Blocks.</i>              |                  |                    |                   |                    |                     |                  |                 |                  |                    |                   |                    |                     |                  |
| 5                                 | 3 $\frac{1}{2}$  | 2 $\frac{1}{2}$    | 3 $\frac{1}{2}$   | 2 $\frac{1}{2}$    | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 13              | 9                | 7 $\frac{1}{2}$    | 9                 | 6 $\frac{1}{2}$    | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 6                                 | 4 $\frac{1}{2}$  | 3 $\frac{1}{2}$    | 4 $\frac{1}{2}$   | 3 $\frac{1}{2}$    | 2                   | 2                | 14              | 9 $\frac{1}{2}$  | 8                  | 10                | 7 $\frac{1}{2}$    | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 7                                 | 4 $\frac{3}{4}$  | 4                  | 5 $\frac{1}{4}$   | 4                  | 2 $\frac{1}{2}$     | 2 $\frac{1}{2}$  | 15              | 10               | 8 $\frac{1}{2}$    | 10 $\frac{1}{2}$  | 8                  | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 8                                 | 5 $\frac{1}{4}$  | 5                  | 6                 | 4 $\frac{1}{4}$    | 3                   | 3                | 16              | 10 $\frac{1}{2}$ | 8 $\frac{1}{2}$    | 11 $\frac{1}{2}$  | 8 $\frac{1}{2}$    | 3                   | 1 $\frac{1}{2}$  |
| 9                                 | 6 $\frac{1}{4}$  | 5 $\frac{1}{2}$    | 6 $\frac{1}{2}$   | 4 $\frac{1}{2}$    | 3 $\frac{1}{2}$     | 3 $\frac{1}{2}$  | 17              | 10 $\frac{1}{2}$ | 8 $\frac{1}{2}$    | 11 $\frac{1}{2}$  | 8 $\frac{1}{2}$    | 3                   | 1 $\frac{1}{2}$  |
| 10                                | 7                | 5 $\frac{3}{4}$    | 7 $\frac{3}{4}$   | 5 $\frac{3}{4}$    | 4                   | 4                | 18              | 11               | 9                  | 12                | 9                  | 3                   | 1 $\frac{1}{2}$  |
| 11                                | 7 $\frac{1}{4}$  | 6                  | 7 $\frac{1}{4}$   | 6 $\frac{1}{4}$    | 4 $\frac{1}{2}$     | 4 $\frac{1}{2}$  | 19              | 11 $\frac{1}{2}$ | 9 $\frac{1}{2}$    | 12 $\frac{1}{2}$  | 9 $\frac{1}{2}$    | 3 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 12                                | 8                | 6 $\frac{1}{2}$    | 8                 | 6 $\frac{1}{2}$    | 5                   | 5                | 20              | 12               | 10                 | 13 $\frac{1}{2}$  | 10                 | 3 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| <i>Clewline Blocks.</i>           |                  |                    |                   |                    |                     |                  |                 |                  |                    |                   |                    |                     |                  |
| 5                                 | 4 $\frac{1}{2}$  | 4 $\frac{1}{2}$    | —                 | 2 $\frac{1}{2}$    | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 8               | 7 $\frac{1}{2}$  | 7                  | —                 | 4                  | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 6                                 | 5 $\frac{1}{2}$  | 5 $\frac{1}{2}$    | —                 | 3 $\frac{1}{2}$    | 2                   | 2                | 10              | 8                | 8                  | —                 | 4 $\frac{1}{2}$    | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 7                                 | 6 $\frac{1}{2}$  | 6 $\frac{1}{2}$    | —                 | 4 $\frac{1}{2}$    | 2 $\frac{1}{2}$     | 2 $\frac{1}{2}$  | 11              | 10               | 9                  | —                 | 5                  | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—  
continued.

| Length of Block             | Breadth of Block | Thickness of Block | Length of Mortice | Thickness of Partition | Distance of Sheave | Thickness of Sheave | Size of Pin-hole | Length of Block | Breadth of Block | Thickness of Block | Length of Mortice | Thickness of Partition | Distance of Sheave | Thickness of Sheave | Size of Pin-hole |
|-----------------------------|------------------|--------------------|-------------------|------------------------|--------------------|---------------------|------------------|-----------------|------------------|--------------------|-------------------|------------------------|--------------------|---------------------|------------------|
| <i>Double-thick Blocks.</i> |                  |                    |                   |                        |                    |                     |                  |                 |                  |                    |                   |                        |                    |                     |                  |
| 3                           | 2 $\frac{1}{2}$  | 2 $\frac{1}{2}$    | 2 $\frac{1}{2}$   | 1                      | 1 $\frac{1}{2}$    | 1 $\frac{1}{2}$     | 1                | 17              | 13               | 11 $\frac{1}{2}$   | 13                | 1 $\frac{1}{2}$        | 10 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 4                           | 3 $\frac{1}{2}$  | 3 $\frac{1}{2}$    | 3 $\frac{1}{2}$   | 1                      | 2                  | 2                   | 1                | 18              | 13 $\frac{1}{2}$ | 12 $\frac{1}{2}$   | 13 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 11 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 5                           | 4                | 3 $\frac{1}{2}$    | 3 $\frac{1}{2}$   | 1                      | 2 $\frac{1}{2}$    | 2 $\frac{1}{2}$     | 1                | 19              | 14 $\frac{1}{2}$ | 12 $\frac{1}{2}$   | 14 $\frac{1}{2}$  | 2                      | 12                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 6                           | 4 $\frac{1}{2}$  | 4 $\frac{1}{2}$    | 4 $\frac{1}{2}$   | 1                      | 3                  | 3                   | 1                | 20              | 15 $\frac{1}{2}$ | 13 $\frac{1}{2}$   | 15 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 12 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 7                           | 5                | 5                  | 5                 | 1                      | 4                  | 4                   | 1                | 21              | 16               | 14 $\frac{1}{2}$   | 16                | 2 $\frac{1}{2}$        | 13                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 8                           | 6                | 6                  | 6                 | 1                      | 5                  | 5                   | 1                | 22              | 16 $\frac{1}{2}$ | 15                 | 16 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 14                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 9                           | 7                | 7                  | 7                 | 1                      | 6                  | 6                   | 1                | 23              | 17 $\frac{1}{2}$ | 15 $\frac{1}{2}$   | 17                | 2 $\frac{1}{2}$        | 14 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 10                          | 7 $\frac{1}{2}$  | 7 $\frac{1}{2}$    | 7 $\frac{1}{2}$   | 1 $\frac{1}{2}$        | 6 $\frac{1}{2}$    | 6 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 24              | 18 $\frac{1}{2}$ | 16                 | 18 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 15                 | 3                   | 1 $\frac{1}{2}$  |
| 11                          | 8                | 8                  | 8                 | 1 $\frac{1}{2}$        | 7                  | 7                   | 1 $\frac{1}{2}$  | 25              | 19               | 16 $\frac{1}{2}$   | 19                | 2 $\frac{1}{2}$        | 15 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 12                          | 9                | 9                  | 9                 | 1 $\frac{1}{2}$        | 7 $\frac{1}{2}$    | 7 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 26              | 19 $\frac{1}{2}$ | 17                 | 19 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 16 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 2                |
| 13                          | 10               | 9                  | 10                | 1 $\frac{1}{2}$        | 8                  | 8                   | 1 $\frac{1}{2}$  | 27              | 20 $\frac{1}{2}$ | 17 $\frac{1}{2}$   | 20                | 2 $\frac{1}{2}$        | 17                 | 3                   | 2                |
| 14                          | 10 $\frac{1}{2}$ | 9 $\frac{1}{2}$    | 10 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 9                  | 9                   | 1 $\frac{1}{2}$  | 28              | 21 $\frac{1}{2}$ | 18                 | 21 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 17 $\frac{1}{2}$   | 3                   | 2 $\frac{1}{2}$  |
| 15                          | 11               | 10 $\frac{1}{2}$   | 11                | 1 $\frac{1}{2}$        | 9 $\frac{1}{2}$    | 9 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 29              | 22               | 18 $\frac{1}{2}$   | 22                | 2 $\frac{1}{2}$        | 18 $\frac{1}{2}$   | 3                   | 2 $\frac{1}{2}$  |
| 16                          | 12 $\frac{1}{2}$ | 11                 | 12 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 10                 | 10                  | 1 $\frac{1}{2}$  | 30              | 22 $\frac{1}{2}$ | 19                 | 22 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 19                 | 3                   | 2 $\frac{1}{2}$  |
| <i>Double-thin Blocks.</i>  |                  |                    |                   |                        |                    |                     |                  |                 |                  |                    |                   |                        |                    |                     |                  |
| 8                           | 6 $\frac{1}{2}$  | 5 $\frac{1}{2}$    | 6 $\frac{1}{2}$   | 1                      | 5 $\frac{1}{2}$    | 5 $\frac{1}{2}$     | 1                | 18              | 14 $\frac{1}{2}$ | 9 $\frac{1}{2}$    | 14 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 12 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 9                           | 7 $\frac{1}{2}$  | 6                  | 7 $\frac{1}{2}$   | 1                      | 6                  | 6                   | 1                | 19              | 15               | 9 $\frac{1}{2}$    | 15                | 1 $\frac{1}{2}$        | 13 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 10                          | 8 $\frac{1}{2}$  | 6 $\frac{1}{2}$    | 8 $\frac{1}{2}$   | 1 $\frac{1}{2}$        | 6 $\frac{1}{2}$    | 6 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 20              | 15 $\frac{1}{2}$ | 10                 | 16                | 1 $\frac{1}{2}$        | 14                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 11                          | 9                | 6 $\frac{1}{2}$    | 9                 | 1 $\frac{1}{2}$        | 7                  | 7                   | 1 $\frac{1}{2}$  | 21              | 16               | 10 $\frac{1}{2}$   | 16 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 14 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 12                          | 9 $\frac{1}{2}$  | 7                  | 9 $\frac{1}{2}$   | 1 $\frac{1}{2}$        | 7 $\frac{1}{2}$    | 7 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 22              | 17 $\frac{1}{2}$ | 10 $\frac{1}{2}$   | 17                | 1 $\frac{1}{2}$        | 15                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 13                          | 10 $\frac{1}{2}$ | 7 $\frac{1}{2}$    | 10 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 8                  | 8                   | 1 $\frac{1}{2}$  | 23              | 18               | 10 $\frac{1}{2}$   | 17 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 15 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 14                          | 11 $\frac{1}{2}$ | 8                  | 11 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 10 $\frac{1}{2}$   | 10 $\frac{1}{2}$    | 1 $\frac{1}{2}$  | 24              | 18 $\frac{1}{2}$ | 10 $\frac{1}{2}$   | 18                | 1 $\frac{1}{2}$        | 16 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 15                          | 12               | 8 $\frac{1}{2}$    | 12                | 1 $\frac{1}{2}$        | 10 $\frac{1}{2}$   | 10 $\frac{1}{2}$    | 1 $\frac{1}{2}$  | 25              | 19               | 10 $\frac{1}{2}$   | 19                | 1 $\frac{1}{2}$        | 17                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 16                          | 12 $\frac{1}{2}$ | 8 $\frac{1}{2}$    | 12 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 11 $\frac{1}{2}$   | 11 $\frac{1}{2}$    | 1 $\frac{1}{2}$  | 26              | 20               | 10 $\frac{1}{2}$   | 20                | 1 $\frac{1}{2}$        | 18 $\frac{1}{2}$   | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 17                          | 13 $\frac{1}{2}$ | 9                  | 13 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 12                 | 12                  | 1 $\frac{1}{2}$  | 27              | 21               | 10 $\frac{1}{2}$   | 21                | 1 $\frac{1}{2}$        | 19                 | 1 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| <i>Treble-thick Blocks.</i> |                  |                    |                   |                        |                    |                     |                  |                 |                  |                    |                   |                        |                    |                     |                  |
| 3                           | 2 $\frac{1}{2}$  | 3 $\frac{1}{2}$    | 2 $\frac{1}{2}$   | 1                      | 1 $\frac{1}{2}$    | 1 $\frac{1}{2}$     | 1                | 17              | 13               | 15 $\frac{1}{2}$   | 13                | 1 $\frac{1}{2}$        | 10 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 4                           | 3 $\frac{1}{2}$  | 4 $\frac{1}{2}$    | 3 $\frac{1}{2}$   | 1                      | 2                  | 2                   | 1                | 18              | 13 $\frac{1}{2}$ | 16 $\frac{1}{2}$   | 13 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 11 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 5                           | 4                | 5                  | 3 $\frac{1}{2}$   | 1                      | 2 $\frac{1}{2}$    | 2 $\frac{1}{2}$     | 1                | 19              | 14 $\frac{1}{2}$ | 17 $\frac{1}{2}$   | 14 $\frac{1}{2}$  | 2                      | 12                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 6                           | 4 $\frac{1}{2}$  | 5 $\frac{1}{2}$    | 4 $\frac{1}{2}$   | 1                      | 3                  | 3                   | 1                | 20              | 15 $\frac{1}{2}$ | 18 $\frac{1}{2}$   | 15 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 12 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 7                           | 5                | 6                  | 5                 | 1                      | 4                  | 4                   | 1                | 21              | 16               | 19 $\frac{1}{2}$   | 16                | 2 $\frac{1}{2}$        | 13                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 8                           | 6                | 7                  | 6                 | 1                      | 5                  | 5                   | 1                | 22              | 16 $\frac{1}{2}$ | 20 $\frac{1}{2}$   | 16 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 14                 | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 9                           | 7                | 8                  | 7                 | 1                      | 6                  | 6                   | 1                | 23              | 17 $\frac{1}{2}$ | 21                 | 17 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 14 $\frac{1}{2}$   | 2 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 10                          | 7 $\frac{1}{2}$  | 9                  | 7 $\frac{1}{2}$   | 1 $\frac{1}{2}$        | 6 $\frac{1}{2}$    | 6 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 24              | 18 $\frac{1}{2}$ | 21 $\frac{1}{2}$   | 18                | 2 $\frac{1}{2}$        | 15                 | 3                   | 1 $\frac{1}{2}$  |
| 11                          | 8                | 10                 | 8                 | 1 $\frac{1}{2}$        | 7                  | 7                   | 1 $\frac{1}{2}$  | 25              | 19               | 22 $\frac{1}{2}$   | 19                | 2 $\frac{1}{2}$        | 15 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 1 $\frac{1}{2}$  |
| 12                          | 9                | 11 $\frac{1}{2}$   | 9                 | 1 $\frac{1}{2}$        | 7 $\frac{1}{2}$    | 7 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 26              | 19 $\frac{1}{2}$ | 23                 | 19 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 16 $\frac{1}{2}$   | 3 $\frac{1}{2}$     | 2                |
| 13                          | 10               | 12                 | 10                | 1 $\frac{1}{2}$        | 8                  | 8                   | 1 $\frac{1}{2}$  | 27              | 20               | 23 $\frac{1}{2}$   | 20                | 2 $\frac{1}{2}$        | 17                 | 3                   | 2                |
| 14                          | 10 $\frac{1}{2}$ | 13                 | 10 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 9                  | 9                   | 1 $\frac{1}{2}$  | 28              | 21 $\frac{1}{2}$ | 24                 | 21 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 17 $\frac{1}{2}$   | 3                   | 2 $\frac{1}{2}$  |
| 15                          | 11               | 13 $\frac{1}{2}$   | 11                | 1 $\frac{1}{2}$        | 9 $\frac{1}{2}$    | 9 $\frac{1}{2}$     | 1 $\frac{1}{2}$  | 29              | 22               | 24 $\frac{1}{2}$   | 22                | 2 $\frac{1}{2}$        | 18 $\frac{1}{2}$   | 3                   | 2 $\frac{1}{2}$  |
| 16                          | 12 $\frac{1}{2}$ | 14                 | 12 $\frac{1}{2}$  | 1 $\frac{1}{2}$        | 10                 | 10                  | 1 $\frac{1}{2}$  | 30              | 22 $\frac{1}{2}$ | 25                 | 22 $\frac{1}{2}$  | 2 $\frac{1}{2}$        | 19                 | 3                   | 2 $\frac{1}{2}$  |



TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—  
continued.*Long-tackle Blocks.*

| Length of Block | Breadth of Upper Sheave | Breadth of Lower Sheave | Thickness of Block | Diameter of Upper Sheave | Diameter of Lower Sheave | Thickness of Sheaves | Length of Upper Mortice | Length of Lower Mortice | Thickness of Mortice | Size of Pin-hole |
|-----------------|-------------------------|-------------------------|--------------------|--------------------------|--------------------------|----------------------|-------------------------|-------------------------|----------------------|------------------|
| 10              | 3 1/2                   | 3 1/2                   | 3 1/2              | 3 1/2                    | 3 1/2                    | 1 1/2                | 4 1/2                   | 3 1/2                   | 1 1/2                | 1 1/2            |
| 11              | 3 3/4                   | 3 3/4                   | 3 3/4              | 4 1/2                    | 3 3/4                    | 1 1/2                | 5 1/2                   | 3 3/4                   | 1 1/2                | 1 1/2            |
| 12              | 3 3/4                   | 3 3/4                   | 3 3/4              | 4 1/2                    | 3 3/4                    | 1 1/2                | 5 1/2                   | 3 3/4                   | 1 1/2                | 1 1/2            |
| 13              | 3 3/4                   | 3 3/4                   | 3 3/4              | 5 1/2                    | 3 3/4                    | 1 1/2                | 6 1/2                   | 4 1/2                   | 1 1/2                | 1 1/2            |
| 14              | 3 3/4                   | 3 3/4                   | 3 3/4              | 5 1/2                    | 4 1/2                    | 1 1/2                | 6 1/2                   | 5 1/2                   | 1 1/2                | 1 1/2            |
| 15              | 3 3/4                   | 3 3/4                   | 3 3/4              | 5 1/2                    | 4 1/2                    | 1 1/2                | 7 1/2                   | 5 1/2                   | 1 1/2                | 1 1/2            |
| 16              | 3 3/4                   | 3 3/4                   | 3 3/4              | 6 1/2                    | 4 1/2                    | 1 1/2                | 7 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 17              | 3 3/4                   | 3 3/4                   | 3 3/4              | 6 1/2                    | 4 1/2                    | 1 1/2                | 7 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 18              | 3 3/4                   | 3 3/4                   | 3 3/4              | 7 1/2                    | 4 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 19              | 3 3/4                   | 3 3/4                   | 3 3/4              | 7 1/2                    | 5 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 20              | 3 3/4                   | 3 3/4                   | 3 3/4              | 8 1/2                    | 5 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 21              | 3 3/4                   | 3 3/4                   | 3 3/4              | 8 1/2                    | 5 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 22              | 3 3/4                   | 3 3/4                   | 3 3/4              | 9 1/2                    | 5 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 23              | 3 3/4                   | 3 3/4                   | 3 3/4              | 9 1/2                    | 6 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 24              | 3 3/4                   | 3 3/4                   | 3 3/4              | 10 1/2                   | 6 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 25              | 3 3/4                   | 3 3/4                   | 3 3/4              | 10 1/2                   | 7 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 26              | 3 3/4                   | 3 3/4                   | 3 3/4              | 11 1/2                   | 7 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 27              | 3 3/4                   | 3 3/4                   | 3 3/4              | 11 1/2                   | 7 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 28              | 3 3/4                   | 3 3/4                   | 3 3/4              | 11 1/2                   | 8 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 29              | 3 3/4                   | 3 3/4                   | 3 3/4              | 12 1/2                   | 8 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |
| 30              | 3 3/4                   | 3 3/4                   | 3 3/4              | 12 1/2                   | 8 1/2                    | 1 1/2                | 8 1/2                   | 6 1/2                   | 1 1/2                | 1 1/2            |

*Topmast-sheer Blocks.*

| Length of Block | Breadth of Block | Thickness of Block | Length of Mortice | Diameter of Sheave | Thickness of Sheave | Size of Pin-hole | Length of Block | Breadth of Block | Thickness of Block | Length of Mortice | Diameter of Sheave | Thickness of Sheave | Size of Pin-hole |
|-----------------|------------------|--------------------|-------------------|--------------------|---------------------|------------------|-----------------|------------------|--------------------|-------------------|--------------------|---------------------|------------------|
| 6               | 4 1/2            | 3 1/2              | 4 1/2             | 3 1/2              | 1 1/2               | 1 1/2            | 13              | 10 1/2           | 6 1/2              | 10 1/2            | 6 1/2              | 1 1/2               | 1 1/2            |
| 7               | 5 1/2            | 3 3/4              | 5 1/2             | 4 1/2              | 1 1/2               | 1 1/2            | 14              | 10 1/2           | 6 1/2              | 10 1/2            | 6 1/2              | 1 1/2               | 1 1/2            |
| 8               | 5 1/2            | 3 3/4              | 5 1/2             | 4 1/2              | 1 1/2               | 1 1/2            | 15              | 11 1/2           | 6 1/2              | 11 1/2            | 6 1/2              | 1 1/2               | 1 1/2            |
| 9               | 6 1/2            | 4 1/2              | 6 1/2             | 5 1/2              | 1 1/2               | 1 1/2            | 16              | 12 1/2           | 6 1/2              | 11 1/2            | 6 1/2              | 1 1/2               | 1 1/2            |
| 10              | 7 1/2            | 4 1/2              | 7 1/2             | 6 1/2              | 1 1/2               | 1 1/2            | 17              | 13 1/2           | 6 1/2              | 12 1/2            | 6 1/2              | 1 1/2               | 1 1/2            |
| 11              | 8 1/2            | 5 1/2              | 8 1/2             | 7 1/2              | 1 1/2               | 1 1/2            | 18              | 13 1/2           | 6 1/2              | 13 1/2            | 6 1/2              | 1 1/2               | 1 1/2            |
| 12              | 9 1/2            | 5 1/2              | 9 1/2             | 8 1/2              | 1 1/2               | 1 1/2            | 19              | 13 1/2           | 6 1/2              | 13 1/2            | 6 1/2              | 1 1/2               | 1 1/2            |

*Nine-pin Blocks.*

|                    |                     |                       |                      |                       |                        |                  |                    |                     |                       |                      |                       |                        |                  |
|--------------------|---------------------|-----------------------|----------------------|-----------------------|------------------------|------------------|--------------------|---------------------|-----------------------|----------------------|-----------------------|------------------------|------------------|
| Length<br>of Block | Breadth<br>of Block | Thickness<br>of Block | Length of<br>Mortice | Diameter<br>of Sheave | Thickness<br>of Sheave | Length<br>of Pin | Length<br>of Block | Breadth<br>of Block | Thickness<br>of Block | Length of<br>Mortice | Diameter<br>of Sheave | Thickness<br>of Sheave | Length<br>of Pin |
| 9                  | 4 1/2               | 3 1/2                 | 4 1/2                | 3 1/2                 | 1 1/2                  | 1 1/2            | 11                 | 5 1/2               | 3 1/2                 | 5 1/2                | 3 1/2                 | 1 1/2                  | 1 1/2            |
| 10                 | 5 1/2               | 3 3/4                 | 5 1/2                | 4 1/2                 | 1 1/2                  | 1 1/2            | 12                 | 6 1/2               | 3 3/4                 | 6 1/2                | 3 3/4                 | 1 1/2                  | 1 1/2            |
| 11                 | 6 1/2               | 4 1/2                 | 6 1/2                | 5 1/2                 | 1 1/2                  | 1 1/2            | 13                 | 7 1/2               | 4 1/2                 | 7 1/2                | 4 1/2                 | 1 1/2                  | 1 1/2            |
| 12                 | 7 1/2               | 4 1/2                 | 7 1/2                | 6 1/2                 | 1 1/2                  | 1 1/2            | 14                 | 8 1/2               | 4 1/2                 | 8 1/2                | 4 1/2                 | 1 1/2                  | 1 1/2            |
| 13                 | 8 1/2               | 5 1/2                 | 8 1/2                | 7 1/2                 | 1 1/2                  | 1 1/2            | 15                 | 9 1/2               | 5 1/2                 | 9 1/2                | 5 1/2                 | 1 1/2                  | 1 1/2            |
| 14                 | 9 1/2               | 5 1/2                 | 9 1/2                | 8 1/2                 | 1 1/2                  | 1 1/2            | 16                 | 10 1/2              | 5 1/2                 | 10 1/2               | 5 1/2                 | 1 1/2                  | 1 1/2            |
| 15                 | 10 1/2              | 6 1/2                 | 10 1/2               | 9 1/2                 | 1 1/2                  | 1 1/2            | 17                 | 11 1/2              | 6 1/2                 | 11 1/2               | 6 1/2                 | 1 1/2                  | 1 1/2            |
| 16                 | 11 1/2              | 6 1/2                 | 11 1/2               | 10 1/2                | 1 1/2                  | 1 1/2            | 18                 | 12 1/2              | 6 1/2                 | 12 1/2               | 6 1/2                 | 1 1/2                  | 1 1/2            |
| 17                 | 12 1/2              | 7 1/2                 | 12 1/2               | 11 1/2                | 1 1/2                  | 1 1/2            | 19                 | 13 1/2              | 7 1/2                 | 13 1/2               | 7 1/2                 | 1 1/2                  | 1 1/2            |
| 18                 | 13 1/2              | 7 1/2                 | 13 1/2               | 12 1/2                | 1 1/2                  | 1 1/2            | 20                 | 14 1/2              | 7 1/2                 | 14 1/2               | 7 1/2                 | 1 1/2                  | 1 1/2            |
| 19                 | 14 1/2              | 8 1/2                 | 14 1/2               | 13 1/2                | 1 1/2                  | 1 1/2            | 21                 | 15 1/2              | 8 1/2                 | 15 1/2               | 8 1/2                 | 1 1/2                  | 1 1/2            |
| 20                 | 15 1/2              | 8 1/2                 | 15 1/2               | 14 1/2                | 1 1/2                  | 1 1/2            | 22                 | 16 1/2              | 8 1/2                 | 16 1/2               | 8 1/2                 | 1 1/2                  | 1 1/2            |
| 21                 | 16 1/2              | 9 1/2                 | 16 1/2               | 15 1/2                | 1 1/2                  | 1 1/2            | 23                 | 17 1/2              | 9 1/2                 | 17 1/2               | 9 1/2                 | 1 1/2                  | 1 1/2            |
| 22                 | 17 1/2              | 9 1/2                 | 17 1/2               | 16 1/2                | 1 1/2                  | 1 1/2            | 24                 | 18 1/2              | 9 1/2                 | 18 1/2               | 9 1/2                 | 1 1/2                  | 1 1/2            |
| 23                 | 18 1/2              | 10 1/2                | 18 1/2               | 17 1/2                | 1 1/2                  | 1 1/2            | 25                 | 19 1/2              | 10 1/2                | 19 1/2               | 10 1/2                | 1 1/2                  | 1 1/2            |
| 24                 | 19 1/2              | 10 1/2                | 19 1/2               | 18 1/2                | 1 1/2                  | 1 1/2            | 26                 | 20 1/2              | 10 1/2                | 20 1/2               | 10 1/2                | 1 1/2                  | 1 1/2            |
| 25                 | 20 1/2              | 11 1/2                | 20 1/2               | 19 1/2                | 1 1/2                  | 1 1/2            | 27                 | 21 1/2              | 11 1/2                | 21 1/2               | 11 1/2                | 1 1/2                  | 1 1/2            |
| 26                 | 21 1/2              | 11 1/2                | 21 1/2               | 20 1/2                | 1 1/2                  | 1 1/2            | 28                 | 22 1/2              | 11 1/2                | 22 1/2               | 11 1/2                | 1 1/2                  | 1 1/2            |
| 27                 | 22 1/2              | 12 1/2                | 22 1/2               | 21 1/2                | 1 1/2                  | 1 1/2            | 29                 | 23 1/2              | 12 1/2                | 23 1/2               | 12 1/2                | 1 1/2                  | 1 1/2            |
| 28                 | 23 1/2              | 12 1/2                | 23 1/2               | 22 1/2                | 1 1/2                  | 1 1/2            | 30                 | 24 1/2              | 12 1/2                | 24 1/2               | 12 1/2                | 1 1/2                  | 1 1/2            |
| 29                 | 24 1/2              | 13 1/2                | 24 1/2               | 23 1/2                | 1 1/2                  | 1 1/2            | 31                 | 25 1/2              | 13 1/2                | 25 1/2               | 13 1/2                | 1 1/2                  | 1 1/2            |
| 30                 | 25 1/2              | 13 1/2                | 25 1/2               | 24 1/2                | 1 1/2                  | 1 1/2            | 32                 | 26 1/2              | 13 1/2                | 26 1/2               | 13 1/2                | 1 1/2                  | 1 1/2            |
| 31                 | 26 1/2              | 14 1/2                | 26 1/2               | 25 1/2                | 1 1/2                  | 1 1/2            | 33                 | 27 1/2              | 14 1/2                | 27 1/2               | 14 1/2                | 1 1/2                  | 1 1/2            |
| 32                 | 27 1/2              | 14 1/2                | 27 1/2               | 26 1/2                | 1 1/2                  | 1 1/2            | 34                 | 28 1/2              | 14 1/2                | 28 1/2               | 14 1/2                | 1 1/2                  | 1 1/2            |
| 33                 | 28 1/2              | 15 1/2                | 28 1/2               | 27 1/2                | 1 1/2                  | 1 1/2            | 35                 | 29 1/2              | 15 1/2                | 29 1/2               | 15 1/2                | 1 1/2                  | 1 1/2            |
| 34                 | 29 1/2              | 15 1/2                | 29 1/2               | 28 1/2                | 1 1/2                  | 1 1/2            | 36                 | 30 1/2              | 15 1/2                | 30 1/2               | 15 1/2                | 1 1/2                  | 1 1/2            |
| 35                 | 30 1/2              | 16 1/2                | 30 1/2               | 29 1/2                | 1 1/2                  | 1 1/2            | 37                 | 31 1/2              | 16 1/2                | 31 1/2               | 16 1/2                | 1 1/2                  | 1 1/2            |
| 36                 | 31 1/2              | 16 1/2                | 31 1/2               | 30 1/2                | 1 1/2                  | 1 1/2            | 38                 | 32 1/2              | 16 1/2                | 32 1/2               | 16 1/2                | 1 1/2                  | 1 1/2            |
| 37                 | 32 1/2              | 17 1/2                | 32 1/2               | 31 1/2                | 1 1/2                  | 1 1/2            | 39                 | 33 1/2              | 17 1/2                | 33 1/2               | 17 1/2                | 1 1/2                  | 1 1/2            |
| 38                 | 33 1/2              | 17 1/2                | 33 1/2               | 32 1/2                | 1 1/2                  | 1 1/2            | 40                 | 34 1/2              | 17 1/2                | 34 1/2               | 17 1/2                | 1 1/2                  | 1 1/2            |
| 39                 | 34 1/2              | 18 1/2                | 34 1/2               | 33 1/2                | 1 1/2                  | 1 1/2            | 41                 | 35 1/2              | 18 1/2                | 35 1/2               | 18 1/2                | 1 1/2                  | 1 1/2            |
| 40                 | 35 1/2              | 18 1/2                | 35 1/2               | 34 1/2                | 1 1/2                  | 1 1/2            | 42                 | 36 1/2              | 18 1/2                | 36 1/2               | 18 1/2                | 1 1/2                  | 1 1/2            |
| 41                 | 36 1/2              | 19 1/2                | 36 1/2               | 35 1/2                | 1 1/2                  | 1 1/2            | 43                 | 37 1/2              | 19 1/2                | 37 1/2               | 19 1/2                | 1 1/2                  | 1 1/2            |
| 42                 | 37 1/2              | 19 1/2                | 37 1/2               | 36 1/2                | 1 1/2                  | 1 1/2            | 44                 | 38 1/2              | 19 1/2                | 38 1/2               | 19 1/2                | 1 1/2                  | 1 1/2            |
| 43                 | 38 1/2              | 20 1/2                | 38 1/2               | 37 1/2                | 1 1/2                  | 1 1/2            | 45                 | 39 1/2              | 20 1/2                | 39 1/2               | 20 1/2                | 1 1/2                  | 1 1/2            |
| 44                 | 39 1/2              | 20 1/2                | 39 1/2               | 38 1/2                | 1 1/2                  | 1 1/2            | 46                 | 40 1/2              | 20 1/2                | 40 1/2               | 20 1/2                | 1 1/2                  | 1 1/2            |
| 45                 | 40 1/2              | 21 1/2                | 40 1/2               | 39 1/2                | 1 1/2                  | 1 1/2            | 47                 | 41 1/2              | 21 1/2                | 41 1/2               | 21 1/2                | 1 1/2                  | 1 1/2            |
| 46                 | 41 1/2              | 21 1/2                | 41 1/2               | 40 1/2                | 1 1/2                  | 1 1/2            | 48                 | 42 1/2              | 21 1/2                | 42 1/2               | 21 1/2                | 1 1/2                  | 1 1/2            |
| 47                 | 42 1/2              | 22 1/2                | 42 1/2               | 41 1/2                | 1 1/2                  | 1 1/2            | 49                 | 43 1/2              | 22 1/2                | 43 1/2               | 22 1/2                | 1 1/2                  | 1 1/2            |
| 48                 | 43 1/2              | 22 1/2                | 43 1/2               | 42 1/2                | 1 1/2                  | 1 1/2            | 50                 | 44 1/2              | 22 1/2                | 44 1/2               | 22 1/2                | 1 1/2                  | 1 1/2            |
| 49                 | 44 1/2              | 23 1/2                | 44 1/2               | 43 1/2                | 1 1/2                  | 1 1/2            | 51                 | 45 1/2              | 23 1/2                | 45 1/2               | 23 1/2                | 1 1/2                  | 1 1/2            |
| 50                 | 45 1/2              | 23 1/2                | 45 1/2               | 44 1/2                | 1 1/2                  | 1 1/2            | 52                 | 46 1/2              | 23 1/2                | 46 1/2               | 23 1/2                | 1 1/2                  | 1 1/2            |
| 51                 | 46 1/2              | 24 1/2                | 46 1/2               | 45 1/2                | 1 1/2                  | 1 1/2            | 53                 | 47 1/2              | 24 1/2                | 47 1/2               | 24 1/2                | 1 1/2                  | 1 1/2            |
| 52                 | 47 1/2              | 24 1/2                | 47 1/2               | 46 1/2                | 1 1/2                  | 1 1/2            | 54                 | 48 1/2              | 24 1/2                | 48 1/2               | 24 1/2                | 1 1/2                  | 1 1/2            |
| 53                 | 48 1/2              | 25 1/2                | 48 1/2               | 47 1/2                | 1 1/2                  | 1 1/2            | 55                 | 49 1/2              | 25 1/2                | 49 1/2               | 25 1/2                | 1 1/2                  | 1 1/2            |
| 54                 | 49 1/2              | 25 1/2                | 49 1/2               | 48 1/2                | 1 1/2                  | 1 1/2            | 56                 | 50 1/2              | 25 1/2                | 50 1/2               | 25 1/2                | 1 1/2                  | 1 1/2            |
| 55                 | 50 1/2              | 26 1/2                | 50 1/2               | 49 1/2                | 1 1/2                  | 1 1/2            | 57                 | 51 1/2              | 26 1/2                | 51 1/2               | 26 1/2                | 1 1/2                  | 1 1/2            |
| 56                 | 51 1/2              | 26 1/2                | 51 1/2               | 50 1/2                | 1 1/2                  | 1 1/2            | 58                 | 52 1/2              | 26 1/2                | 52 1/2               | 26 1/2                | 1 1/2                  | 1 1/2            |
| 57                 | 52 1/2              | 27 1/2                | 52 1/2               | 51 1/2                | 1 1/2                  | 1 1/2            | 59                 | 53 1/2              | 27 1/2                | 53 1/2               | 27 1/2                | 1 1/2                  | 1 1/2            |
| 58                 | 53 1/2              | 27 1/2                | 53 1/2               | 52 1/2                | 1 1/2                  | 1 1/2            | 60                 | 54 1/2              | 27 1/2                | 54 1/2               | 27 1/2                | 1 1/2                  | 1 1/2            |
| 59                 | 54 1/2              | 28 1/2                | 54 1/2               | 53 1/2                | 1 1/2                  | 1 1/2            | 61                 | 55 1/2              | 28 1/2                | 55 1/2               | 28 1/2                | 1 1/2                  | 1 1/2            |
| 60                 | 55 1/2              | 28 1/2                | 55 1/2               | 54 1/2                | 1 1/2                  | 1 1/2            | 62                 | 56 1/2              | 28 1/2                | 56 1/2               | 28 1/2                | 1 1/2                  | 1 1/2            |
| 61                 | 56 1/2              | 29 1/2                | 56 1/2               | 55 1/2                | 1 1/2                  | 1 1/2            | 63                 | 57 1/2              | 29 1/2                | 57 1/2               | 29 1/2                | 1 1/2                  | 1 1/2            |
| 62                 | 57 1/2              | 29 1/2                | 57 1/2               | 56 1/2                | 1 1/2                  | 1 1/2            | 64                 | 58 1/2              | 29 1/2                | 58 1/2               | 29 1/2                | 1 1/2                  | 1 1/2            |
| 63                 | 58 1/2              | 30 1/2                | 58 1/2               | 57 1/2                | 1 1/2                  | 1 1/2            | 65                 | 59 1/2              | 30 1/2                | 59 1/2               | 30 1/2                | 1 1/2                  | 1 1/2            |
| 64                 | 59 1/2              | 30 1/2                | 59 1/2               | 58 1/2                | 1 1/2                  | 1 1/2            | 66                 | 60 1/2              | 30 1/2                | 60 1/2               | 30 1/2                | 1 1/2                  | 1 1/2            |
| 65                 | 60 1/2              | 31 1/2                | 60 1/2               | 59 1/2                | 1 1/2                  | 1 1/2            | 67                 | 61 1/2              | 31 1/2                | 61 1/2               | 31 1/2                | 1 1/2                  | 1 1/2            |
| 66                 | 61 1/2              | 31 1/2                | 61 1/2               | 60 1/2                | 1 1/2                  | 1 1/2            | 68                 | 62 1/2              | 31 1/2                | 62 1/2               | 31 1/2                | 1 1/2                  | 1 1/2            |
| 67                 | 62 1/2              | 32 1/2                | 62 1/2               | 61 1/2                | 1 1/2                  | 1 1/2            | 69                 | 63 1/2              | 32 1/2                | 63 1/2               | 32 1/2                | 1 1/2                  | 1 1/2            |
| 68                 | 63 1/2              | 32 1/2                | 63 1/2               | 62 1/2                | 1 1/2                  | 1 1/2            | 70                 | 64 1/2              | 32 1/2                | 64 1/2               | 32 1/2                | 1 1/2                  | 1 1/2            |
| 69                 | 64 1/2              | 33 1/2                | 64 1/2               | 63 1/2                | 1 1/2                  | 1 1/2            | 71                 | 65 1/2              | 33 1/2                | 65 1/2               | 33 1/2                | 1 1/2                  | 1 1/2            |
| 70                 | 65 1/2              | 33 1/2                | 65 1/2               | 64 1/2                | 1 1/2                  | 1 1/2            | 72                 | 66 1/2              | 33 1/2                | 66 1/2               | 33 1/2                | 1 1/2                  | 1 1/2            |
| 71                 | 66 1/2              | 34 1/2                | 66 1/2               | 65 1/2                | 1 1/2                  | 1 1/2            | 73                 | 67 1/2              | 34 1/2                | 67 1/2               | 34 1/2                | 1 1/2                  | 1 1/2            |
| 72                 | 67 1/2              | 34 1/2                | 67 1/2               | 66 1/2                | 1 1/2                  | 1 1/2            | 74                 | 68 1/2              | 34 1/2                | 68 1/2               | 34 1/2                | 1 1/2                  | 1 1/2            |
| 73                 | 68 1/2              | 35 1/2                | 68 1/2               | 67 1/2                | 1 1/2                  | 1 1/2            | 75                 | 69 1/2              | 35 1/2                | 69 1/2               | 35 1/2                | 1 1/2                  | 1 1/2            |
| 74                 | 69 1/2              | 35 1/2                | 69 1/2               | 68 1/2                | 1 1/2                  | 1 1/2            | 76                 | 70 1/2              | 35 1/2                | 70 1/2               | 35 1/2                | 1 1/2                  | 1 1/2            |
| 75                 | 70 1/2              | 36 1/2                | 70 1/2               | 69 1/2                | 1 1/2                  | 1 1/2            | 77                 | 71 1/2              | 36 1/2                | 71 1/2               | 36 1/2                | 1 1/2                  | 1 1/2            |
| 76                 | 71 1/2              | 36 1/2                | 71 1/2               | 70 1/2                | 1 1/2                  | 1 1/2            | 78                 | 72 1/2              | 36 1/2                | 72 1/2               | 36 1/2                | 1 1/2                  | 1 1/2            |
| 77                 | 72 1/2              | 37 1/2                | 72 1/2               | 71 1/2                | 1 1/2                  | 1 1/2            | 79                 | 73 1/2              | 37 1/2                | 73 1/2               | 37 1/2                | 1 1/2                  | 1 1/2            |
| 78                 | 73 1/2              | 37 1/2                | 73 1/2               | 72 1/2                | 1 1/2                  | 1 1/2            | 80                 | 74 1/2              | 37 1/2                | 74 1/2               | 37 1/2                | 1 1/2                  | 1 1/2            |
| 79                 | 74 1/2              | 38 1/2                | 74 1/2               | 73 1/2                | 1 1/2                  | 1 1/2            | 81                 | 75 1/2              | 38 1/2                | 75 1/2               | 38 1/2                | 1 1/2                  | 1 1/2            |
| 80                 | 75 1/2              | 38 1/2                | 75 1/2               | 74 1/2                | 1 1/2                  | 1 1/2            | 82                 | 76 1/2              | 38 1/2                | 76 1/2               | 38 1/2                | 1 1/2                  | 1 1/2            |
| 81                 | 76 1/2              | 39 1/2                | 76 1/2               | 75 1/2                | 1 1/2                  | 1 1/2            | 83                 | 77 1/2              | 39 1/2                | 77 1/2               | 39 1/2                | 1 1/2                  | 1 1/2            |
| 82                 | 77 1/2              | 39 1/2                | 77 1/2               | 76 1/2                | 1 1/2                  | 1 1/2            | 84                 | 78 1/2              | 39 1/2                | 78 1/2               | 39 1/2                | 1 1/2                  | 1 1/2            |
| 83                 | 78 1/2              | 40 1/2                | 78 1/2               | 77 1/2                | 1 1/2                  | 1 1/2            | 85                 | 79 1/2              | 40 1/2                | 79 1/2               | 40 1/2                | 1 1/2                  | 1 1/2            |
| 84                 | 79 1/2              | 40 1/2                | 79 1/2               | 78 1/2                | 1 1/2                  | 1 1/2            | 86                 | 80 1/2              | 40 1/2                | 80 1/2               | 40 1/2                | 1 1/2                  | 1 1/2            |
| 85                 | 80 1/2              | 41 1/2                | 80 1/2               | 79 1/2                | 1 1/2                  | 1 1/2            | 87                 | 81 1/2              | 41 1/2                | 81 1/2               | 41 1/2                | 1 1/2                  | 1 1/2            |
| 86                 | 81 1/2              | 41 1/2                | 81 1/2               | 80 1/2                | 1 1/2                  | 1 1/2            | 88                 | 82 1/2              | 41 1/2                | 82 1/2               | 41 1/2                | 1 1/2                  | 1 1/2            |
| 87                 | 82 1/2              | 42 1/2                | 82 1/2               | 81 1/2                | 1 1/2                  | 1 1/2            | 89                 | 83 1/2              | 42 1/2                | 83 1/2               | 42 1/2                | 1 1/2                  | 1 1/2            |
| 88                 | 83 1/2              | 42 1/2                | 83 1/2               | 82 1/2                | 1 1/2                  | 1 1/2            | 90                 | 84 1/2              | 42 1/2                | 84 1/2               | 42 1/2                | 1 1/2                  | 1 1/2            |
| 89                 | 84 1/2              | 43 1/2                | 84 1/2               | 83 1/2                | 1 1/2                  | 1 1/2            | 91                 | 85 1/2              | 43 1/2                | 85 1/2               | 43 1/2                | 1 1/2                  | 1 1/2            |
| 90                 | 85 1/2              | 43 1/2                | 85 1/2               | 84 1/2                | 1 1/2                  | 1 1/2            | 92                 | 86 1/2              | 43 1/2                | 86 1/2               | 43 1/2                | 1 1/2                  | 1 1/2            |
| 91                 | 86 1/2              | 44 1/2                | 86 1/2               | 85 1/2                | 1 1/2                  | 1 1/2            | 93                 | 87 1/2              | 44 1/2                | 87 1/2               | 44 1/2                | 1 1/2                  | 1 1/2            |
| 92                 | 87 1/2              | 44 1/2                | 87 1/2               | 86 1/2                | 1 1/2                  | 1 1/2            | 94                 | 88 1/2              | 44 1/2                | 88 1/2               | 44 1/2                | 1 1/2                  | 1 1/2            |
| 93                 | 88 1/2              | 45 1/2                | 88                   |                       |                        |                  |                    |                     |                       |                      |                       |                        |                  |

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—  
continued.

| <i>Snatch Blocks.</i> |                  |                    |                   |                      |                    |                     |                  |                 |                  |                    |                   |                      |
|-----------------------|------------------|--------------------|-------------------|----------------------|--------------------|---------------------|------------------|-----------------|------------------|--------------------|-------------------|----------------------|
| Length of Block       | Breadth of Block | Thickness of Block | Length of Mortice | Thickness of Mortice | Diameter of Sheave | Thickness of Sheave | Size of Pin hole | Length of Block | Breadth of Block | Thickness of Block | Length of Mortice | Thickness of Mortice |
| 7                     | 3                | 3                  | 0                 | 1                    | 3                  | 1                   | 1                | 17              | 9                | 7                  | 11                | 3                    |
| 8                     | 4                | 3                  | 1                 | 1                    | 3                  | 1                   | 1                | 18              | 10               | 7                  | 11                | 3                    |
| 9                     | 4                | 4                  | 1                 | 1                    | 3                  | 1                   | 1                | 19              | 10               | 8                  | 12                | 3                    |
| 10                    | 5                | 4                  | 1                 | 1                    | 4                  | 1                   | 1                | 20              | 11               | 8                  | 13                | 3                    |
| 11                    | 5                | 5                  | 1                 | 1                    | 4                  | 1                   | 1                | 21              | 11               | 9                  | 14                | 3                    |
| 12                    | 6                | 5                  | 1                 | 1                    | 5                  | 1                   | 1                | 22              | 12               | 9                  | 14                | 3                    |
| 13                    | 7                | 5                  | 1                 | 1                    | 5                  | 1                   | 1                | 23              | 12               | 9                  | 15                | 3                    |
| 14                    | 7                | 6                  | 1                 | 2                    | 6                  | 1                   | 1                | 24              | 13               | 10                 | 16                | 3                    |
| 15                    | 8                | 6                  | 2                 | 2                    | 6                  | 1                   | 1                | 25              | 13               | 10                 | 16                | 3                    |
| 16                    | 8                | 7                  | 2                 | 2                    | 7                  | 2                   | 1                | 26              | 14               | 11                 | 17                | 3                    |

| <i>Single-aster Blocks.</i> |                   |                    |                     |                  |                 |                   |                    |                     |                  |                 |                   |                    |
|-----------------------------|-------------------|--------------------|---------------------|------------------|-----------------|-------------------|--------------------|---------------------|------------------|-----------------|-------------------|--------------------|
| Length of Block             | Diameter of Block | Diameter of Sheave | Thickness of Sheave | Size of Pin hole | Length of Block | Diameter of Block | Diameter of Sheave | Thickness of Sheave | Size of Pin hole | Length of Block | Diameter of Block | Diameter of Sheave |
| 5                           | 3                 | 2                  | 1                   | 1                | 7               | 4                 | 3                  | 1                   | 1                | 9               | 4                 | 4                  |
| 6                           | 3                 | 2                  | 1                   | 1                | 8               | 4                 | 3                  | 1                   | 1                | 10              | 4                 | 4                  |

| <i>Double-aster Blocks.</i> |                   |                    |                     |                  |                   |                    |                     |                  |                 |                   |                    |                     |
|-----------------------------|-------------------|--------------------|---------------------|------------------|-------------------|--------------------|---------------------|------------------|-----------------|-------------------|--------------------|---------------------|
| Length of Block             | Diameter of Block | Diameter of Sheave | Thickness of Sheave | Size of Pin hole | Diameter of Block | Diameter of Sheave | Thickness of Sheave | Size of Pin hole | Length of Block | Diameter of Block | Diameter of Sheave | Thickness of Sheave |
| 10                          | 5                 | 3                  | 1                   | 1                | 11                | 5                  | 3                   | 1                | 12              | 5                 | 3                  | 1                   |
| 11                          | 5                 | 3                  | 1                   | 1                | 13                | 5                  | 3                   | 1                | 14              | 5                 | 3                  | 1                   |
| 12                          | 5                 | 3                  | 1                   | 1                | 15                | 5                  | 3                   | 1                | 16              | 5                 | 3                  | 1                   |
| 13                          | 5                 | 3                  | 1                   | 1                | 17                | 5                  | 3                   | 1                | 18              | 5                 | 3                  | 1                   |
| 14                          | 5                 | 3                  | 1                   | 1                | 19                | 5                  | 3                   | 1                | 20              | 5                 | 3                  | 1                   |
| 15                          | 5                 | 3                  | 1                   | 1                | 21                | 5                  | 3                   | 1                | 22              | 5                 | 3                  | 1                   |
| 16                          | 5                 | 3                  | 1                   | 1                | 23                | 5                  | 3                   | 1                | 24              | 5                 | 3                  | 1                   |

| <i>Trucks.</i>     |   |   |   |   |   |    |    |    |    |        |        |        |
|--------------------|---|---|---|---|---|----|----|----|----|--------|--------|--------|
| Diameter of Truck  | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |        |        |        |
| Thickness of Truck | 1 | 1 | 1 | 2 | 2 | 2  | 2  | 2  | 3  |        |        |        |
| No. of Sheaves     | 3 | 3 | 3 | 3 | 3 | 3  | 3  | 3  | 3  | Double | Double | Double |

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—  
concluded.

| <i>Dead-eyes.</i>     |                 |                 |         |         |                 |                 |         |                 |         |                 |                  |
|-----------------------|-----------------|-----------------|---------|---------|-----------------|-----------------|---------|-----------------|---------|-----------------|------------------|
| Length                | Breadth         | Thickness       | Length  | Breadth | Thickness       | Length          | Breadth | Thickness       | Length  | Breadth         | Thickness        |
| 5                     | 5               | 3               | 9       | 9       | 5 $\frac{1}{2}$ | 13              | 13      | 8               | 17      | 17              | 10               |
| 6                     | 6               | 4               | 10      | 10      | 6 $\frac{1}{2}$ | 14              | 14      | 8 $\frac{1}{2}$ | 18      | 18              | 10 $\frac{1}{2}$ |
| 7                     | 7               | 4 $\frac{1}{2}$ | 11      | 11      | 7               | 15              | 15      | 9               | 19      | 19              | 11               |
| 8                     | 8               | 5               | 12      | 12      | 7 $\frac{1}{2}$ | 16              | 16      | 9 $\frac{1}{2}$ | —       | —               | —                |
| <i>Closed Hearts.</i> |                 |                 |         |         |                 |                 |         |                 |         |                 |                  |
| Length                | Breadth         | Thickness       | Gauging | Length  | Breadth         | Thickness       | Gauging | Length          | Breadth | Thickness       | Gauging          |
| 5                     | 4               | 3               | 1       | 9       | 7               | 5               | 2       | 13              | 10      | 7               | 3                |
| 6                     | 4 $\frac{1}{2}$ | 3 $\frac{1}{2}$ | 1       | 10      | 8               | 5 $\frac{1}{2}$ | 2       | 14              | 11      | 7 $\frac{1}{2}$ | 3 $\frac{1}{2}$  |
| 7                     | 5               | 4               | 1       | 11      | 9               | 6               | 2       | 15              | 12      | 8               | 4                |
| 8                     | 5 $\frac{1}{2}$ | 4 $\frac{1}{2}$ | 1       | 12      | 10              | 6 $\frac{1}{2}$ | 2       | 16              | 13      | 8 $\frac{1}{2}$ | 4 $\frac{1}{2}$  |
| <i>Open Hearts.</i>   |                 |                 |         |         |                 |                 |         |                 |         |                 |                  |
| Length                | Breadth         | Thickness       | Gauging | Length  | Breadth         | Thickness       | Gauging | Length          | Breadth | Thickness       | Gauging          |
| 5                     | 4               | 3               | 1       | 9       | 8               | 6               | 1       | 13              | 12      | 8               | 1                |
| 6                     | 5               | 4               | 1       | 10      | 9               | 6 $\frac{1}{2}$ | 1       | 14              | 13      | 8 $\frac{1}{2}$ | 1                |
| 7                     | 6               | 5               | 1       | 11      | 10              | 7               | 1       | 15              | 14      | 9               | 1                |
| 8                     | 7               | 6               | 1       | 12      | 11              | 7 $\frac{1}{2}$ | 1       | 16              | 15      | 9 $\frac{1}{2}$ | 1                |

TABLE OF THE VALUE OF THE BELGIAN GAUGE IN  
DECIMALS OF AN INCH.

| Mark | Size | Mark | Size | Mark | Size | Mark | Size | Mark | Size |
|------|------|------|------|------|------|------|------|------|------|
| 1    | ·004 | 7    | ·015 | 13   | ·034 | 19   | ·067 | 25   | ·111 |
| 2    | ·006 | 8    | ·017 | 14   | ·037 | 20   | ·074 | 26   | ·120 |
| 3    | ·008 | 9    | ·019 | 15   | ·041 | 21   | ·082 | —    | —    |
| 4    | ·009 | 10   | ·022 | 16   | ·045 | 22   | ·089 | —    | —    |
| 5    | ·011 | 11   | ·026 | 17   | ·052 | 23   | ·097 | —    | —    |
| 6    | ·013 | 12   | ·030 | 18   | ·059 | 24   | ·104 | —    | —    |

# VOCABULARY OF TECHNICAL TERMS USED IN SHIPBUILDING.

## ENGLISH—FRENCH.

|  |   |
|--|---|
| <b>Abaft</b> , en arrière  | <b>Bitts</b> , bittes                                     |
| <b>Aboard</b> , à bord   | <b>Blade of a screw</b> , aile d'hélice                   |
| <b>Admiral</b> , amiral  | <b>Blister steel</b> , acier poule                        |
| <b>Admiralty</b> , amirauté  | <b>Block</b> , poulie, moufle                             |
| <b>Adze</b> , herminette   | <b>Block and fall</b> , palan                             |
| <b>Afloat</b> , à flot   | <b>Boarding pike</b> , pique d'abordage                   |
| <b>Aft</b> , arrière, de l'arrière   | <b>Boat</b> , bateau, canot                               |
| <b>Air pump</b> , pompe à air  | <b>Boatswain</b> , maître d'équipage                      |
| <b>A-lee</b> , sous le vent  | <b>Bobstay</b> , sous-barbe                               |
| <b>Amidships</b> , au milieu du navire   | <b>Body plan</b> , plan vertical                          |
| <b>Anchor</b> , ancre  | <b>Boiler maker</b> , chaudronnier                        |
| <b>Angle iron</b> , cornière, fer d'angle                                      | <b>Boiler plate</b> , tôle                                |
| <b>Apron</b> , radier, contre - étrave,<br>platine                             | <b>Bollard</b> , corps mort                               |
| <b>Ash</b> , frêne   | <b>Bolt</b> , cheville, boulon                            |
| <b>Astern</b> , à l'arrière, de l'arrière                                      | <b>Bolt rope</b> , ralingue                               |
| <b>Athwart</b> , par le travers  | <b>Boom</b> , bout dehors, arc-boutant                    |
| <b>Awning</b> , tente  | <b>Bow</b> , l'avant d'un vaisseau                        |
| <b>Azimuth compass</b> , compas de<br>variation                                | <b>Bower-anchor</b> , ancre du bossoir                    |
| <b>Back of stern-post</b> , contre-<br>étambot                                 | <b>Bowsprit</b> , beaupré                                 |
| <b>Backstay</b> , galhauban  | <b>Brace</b> , bras                                       |
| <b>Barge</b> , grand canot, allège   | <b>Bracket</b> , courbaton                                |
| <b>Bar iron</b> , fer en barres  | <b>Brail</b> , cargue                                     |
| <b>Barque</b> , barque, bateau   | <b>Bread room</b> , soute au pain                         |
| <b>Barrel of the capstan</b> , mèche du<br>cabestan                            | <b>Breadth extreme</b> , plus grande<br>largeur           |
| <b>Barrel of the steering wheel</b> ,<br>tambour de la roue du gou-<br>vernail | <b>Breaker</b> , brisant, baril de galère                 |
| <b>Batten</b> , liteau   | <b>Breast-plate</b> , conscience                          |
| <b>Beam</b> , bau  | <b>Brig</b> , brig  |
| <b>Beech</b> , hêtre   | <b>Brigantine</b> , brigantin                             |
| <b>Bending press</b> , machine à cin-<br>trer les tôles                        | <b>Bucket</b> , baille                                    |
| <b>Between-decks</b> , entrepont   | <b>Builder</b> , constructeur                             |
| <b>Bevel</b> , angle oblique, angle<br>d'équerrage                             | <b>Bulk head</b> , cloison                                |
| <b>Bilge</b> , petit fond d'un navire  | <b>Bunker</b> , soute                                     |
| <b>Bilge pump</b> , pompe de cale  | <b>Bunt-line</b> , cargue-fond                            |
| <b>Bilge ways</b> , coittes  | <b>Buoy</b> , bouée, balise                               |
| <b>Binnacle</b> , habitacle  | <b>Buoyant</b> , léger, émergé                            |
|  | <b>Burton</b> , petit palan                               |
|  | <b>Butt</b> , about, tête d'un couple                     |
|  | <b>Butt cover</b> , plaque de jonction<br>d'écart de tôle |
|  | <b>Cabin</b> , cabine, chambre, lit                       |
|  | <b>Cable</b> , câble                                      |
|  | <b>Cable tier</b> , fosse aux câbles                      |

## ENGLISH INTO FRENCH (continued).

|  |   |
|--|---|
| <b>Caisson</b> , bateau-porte              | <b>Crane</b> , grue   |
| <b>Cant</b> , oblique, tringle             | <b>Crank shaft</b> , arbre à manivelle                          |
| <b>Cant timbers</b> , couples dévoyés      | <b>Cringle</b> , aguiée, ancette                                |
| <b>Capstan</b> , cabestan                  | <b>Cross-tree</b> , barre de hune                               |
| <b>Careen</b> , carène                     | <b>Crow-bar</b> , presson, pince                                |
| <b>Cargo</b> , cargaison, chargement       | <b>Cruiser</b> , croiseur                                       |
| <b>Carling</b> , entremise, aillure        | <b>Crutches</b> , fourcats                                      |
| <b>Cast iron</b> , fonte de fer            | <b>Cutter</b> , cutter, cotre                                   |
| <b>Cast-iron girder</b> , poutre en fonte  | <b>Cutwater</b> , taille-mer, éperon                            |
| <b>Cast iron pipe</b> , tuyau en fonte     | <b>Davit</b> , davier   |
| <b>Cast steel</b> , acier fondu            | <b>Dead-eyes</b> , caps de mouton                               |
| <b>Cat-head</b> , bossoir                  | <b>Dead-light</b> , faux mantelet                               |
| <b>Cat's-paw</b> , fraîcheur, petite brise | <b>Dead-wood</b> , courbes de remplissage                       |
| <b>Caulk (to)</b> , calfater               | <b>Deal</b> , bordage mince                                     |
| <b>Caulker</b> , calfat                    | <b>Deck</b> , pont, tillac                                      |
| <b>Chain</b> , chaîne, câble-chaîne        | <b>Deck planks</b> , bordages des ponts                         |
| <b>Cheeks of a mast</b> , jottereaux       | <b>Deck stopper</b> , bosse à bouton                            |
| <b>Clack valve</b> , clapet                | <b>Delivery pipe</b> , tuyau d'écoulement                       |
| <b>Clamp</b> , bauquière, jumelle          | <b>Delivery valve</b> , clapet de décharge                      |
| <b>Cleat</b> , taquet                      | <b>Depth of hold</b> , creux de cale                            |
| <b>Clew</b> , point d'écoute               | <b>Distilling apparatus</b> , appareil distillatoire            |
| <b>Clew garnets</b> , cargues-points       | <b>Dock</b> , bassin, darse                                     |
| <b>Coal bunker</b> , soute alimentaire     | <b>Dockyard</b> , arsenal                                       |
| <b>Coamings</b> , chambranles              | <b>Down-haul</b> , hale-bas                                     |
| <b>Coaster</b> , cabotier                  | <b>Draught of water</b> , tirant d'eau                          |
| <b>Cockpit</b> , théâtre                   | <b>Dredging machine</b> , cure-môle à vapeur, machine à draguer |
| <b>Cockswain</b> , patron de chaloupe      | <b>Drill</b> , foret, mèche                                     |
| <b>Coffer-dam</b> , batardeau              | <b>Drilling machine</b> , machine à percer                      |
| <b>Commander</b> , capitaine de frégate    | <b>Driver</b> , tapecul, paille-en-cul                          |
| <b>Companion</b> , capot d'échelle         | <b>Driving wheel</b> , roue motrice                             |
| <b>Compass</b> , boussole, compas de route | <b>Drum</b> , tambour   |
| <b>Copper</b> , cuivre                     | <b>Dry dock</b> , forme sèche, forme de radoub                  |
| <b>Copper-bottomed</b> , doublé en cuivre  | <b>Dunnage</b> , fardage  |
| <b>Cordage</b> , cordages                  | <b>Ebb</b> , reflux, jusant                                     |
| <b>Corvette</b> , corvette                 | <b>Elevation</b> , élévation, projection verticale              |
| <b>Counter</b> , grande voûte              | <b>Elm</b> , orme   |
| <b>Countersink</b> , fraisure              | <b>Endless chain</b> , chaîne sans fin                          |
| <b>Countersunk head</b> , tête fraisée     | <b>Engine</b> , machine   |
| <b>Course</b> , route, basse-voile         | <b>Engine-bearer</b> , carlingue                                |
| <b>Crab</b> , cabestan volant              |   |
| <b>Crab winch</b> , virevaut, treuil       |   |
| <b>Cradle</b> , berceau                    |   |
| <b>Craft</b> , petit navire                |   |

## ENGLISH INTO FRENCH (continued).

|  |  |
|--|--|
| <b>Engine room</b> , chambre de la machine                 | la trinquette du petit foc, <i>or</i> du tourmentin  |
| <b>Ensign</b> , pavillon de poupe                          | <b>Fore topgallant mast</b> , petit mât de perroquet |
| <b>Eye bolt</b> , cheville à œillet                        | <b>Fore topmast</b> , petit mât de hune              |
| <b>False keel</b> , fausse quille                          | <b>Fore topmast stay</b> , étai du petit hunier      |
| <b>Fathom</b> , brasse                                     | <b>Fore topsail braces</b> , bras du petit hunier    |
| <b>Feathering paddle</b> , aube articulée                  | <b>Foundation plate</b> , plaque de fondation        |
| <b>Feathering paddle-wheel</b> , roue à aubes articulées   | <b>Four-way cock</b> , robinet à quatre fins         |
| <b>Feed pump</b> , pompe alimentaire                       | <b>Frame</b> , couple                                |
| <b>Fender</b> , défense                                    | <b>Framing</b> , bâtis <i>or</i> charpente           |
| <b>Ferry</b> , gué   | <b>Funnel</b> , cheminée en tôle                     |
| <b>Ferry boat</b> , bateau de passage                      | <b>Furnace</b> , fourneau, foyer                     |
| <b>Fid</b> , clef  | <b>Futtock</b> , allonge                             |
| <b>Figured dimension</b> , quote                           | <b>Gaff</b> , pic, corne d'artimon                   |
| <b>File</b> , lime   | <b>Gaff topsail</b> , flèche-en-cul                  |
| <b>Filling piece</b> , pièce de remplissage                | <b>Gallant mast</b> , mât de perroquet               |
| <b>Fir wood</b> , sapin                                    | <b>Gallant sail</b> , voile de perroquet             |
| <b>Fire ship</b> , brûlot                                  | <b>Galvanised iron</b> , fer galvanisé               |
| <b>Fish pendant</b> , pantoire de la candelette de l'ancre | <b>Gammoning</b> , liure                             |
| <b>Fish-tackle fall</b> , garant de la candelette          | <b>Garboard strake</b> , virure de gabord            |
| <b>Flange</b> , collerette, collet                         | <b>General drawing</b> , dessin d'ensemble           |
| <b>Flange joint</b> , joint à collet                       | <b>Girder</b> , poutre                               |
| <b>Flare</b> , revers                                      | <b>Girt</b> , ceinturé                               |
| <b>Floating body</b> , corps flottant                      | <b>Goose-neck</b> , cou de cygne                     |
| <b>Floor</b> , fond d'un navire                            | <b>Grapple</b> , grappin                             |
| <b>Floor heads</b> , têtes des varangues                   | <b>Graving dock</b> , forme de radoub                |
| <b>Floor timbers</b> , varangues                           | <b>Grummet</b> , estrope                             |
| <b>Flukes</b> , oreilles d'une ancre                       | <b>Gunboat</b> , chaloupe canonnière                 |
| <b>Flush deck</b> , pont entier                            | <b>Gun carriage</b> , affût                          |
| <b>Flush joint</b> , assemblage bout à bout                | <b>Gun metal</b> , bronze de canon                   |
| <b>Flush rivet</b> , rivet à tête fraisée                  | <b>Gun port</b> , sabord                             |
| <b>Fly wheel</b> , volant                                  | <b>Gunwale</b> , plat-bord                           |
| <b>Flying jib</b> , petit foc, clinfoc                     | <b>Guy</b> , cordage de retenue                      |
| <b>Flying jibboom</b> , bout dehors de clinfoc             | <b>Half-breadth plan</b> , plan horizontal           |
| <b>Force pump</b> , pompe foulante                         | <b>Halliard</b> , drisse                             |
| <b>Forecastle</b> , gaillard d'avant                       | <b>Hammock</b> , hamac                               |
| <b>Fore mast</b> , mât de misaine                          | <b>Hand pump</b> , pompe à bras                      |
| <b>Fore sheets</b> , écoute                                | <b>Handspike</b> , anspect                           |
| <b>Fore stay</b> , étai de misaine                         |  |
| <b>Fore staysail halliard</b> , drisse de                  |  |

## ENGLISH INTO FRENCH (continued).

|  |  |
|--|--|
| <b>Hard a-lee</b> , lof tout                       | <b>Kedge anchor</b> , ancre à jet                    |
| <b>Hard a-port</b> , la barre toute à bâbord       | <b>Keel</b> , quille                                 |
| <b>Hard a-starboard</b> , la barre à tribord toute | <b>Keelson</b> , carlingue                           |
| <b>Hard a-weather</b> , la barre toute au vent     | <b>Kingston's valve</b> , soupape du navire          |
| <b>Harpings</b> , préceintes renforcées de l'avant | <b>Knee</b> , courbe, genou                          |
| <b>Hatch</b> , panneau                             | <b>Knight-heads</b> , bouts des apôtres, bittons     |
| <b>Hatchway</b> , écoutille                        | <b>Knot</b> , nœud, bouton                           |
| <b>Hawse pipes</b> , plombs des écubiers           | <b>Ladder</b> , échelle                              |
| <b>Hawseplug</b> , tampon des écubiers             | <b>Lap or cover</b> , recouvrement                   |
| <b>Hawser</b> , aussière                           | <b>Lapped joint</b> , joint superposé, joint à clin  |
| <b>Head sails</b> , voiles de l'avant              | <b>Larboard</b> , bâbord                             |
| <b>Helm</b> , gouvernail                           | <b>Lashing</b> , aiguillette, fouet                  |
| <b>Hemp</b> , chanvre                              | <b>Lateen sail</b> , voile latine                    |
| <b>High water</b> , pleine mer                     | <b>Lateen yard</b> , antenne                         |
| <b>Hinge</b> , penture, gond                       | <b>Lathe</b> , tour                                  |
| <b>Hog</b> , goret d'un navire                     | <b>Launch</b> , avant-cale                           |
| <b>Hold</b> , cale                                 | <b>Lead</b> , plomb                                  |
| <b>Hoop iron</b> , feuillard, fer à ruban          | <b>Leak</b> , fuite, voie d'eau                      |
| <b>Horse box</b> , wagon-écurie                    | <b>Leeboard</b> , semelle de dérive                  |
| <b>Horse power</b> , cheval de vapeur              | <b>Lee side</b> , côté sous le vent                  |
| <b>Hounds</b> , jottereaux                         | <b>Leech rope</b> , ralingue de chute                |
| <b>Hulk</b> , ponton, cayenne                      | <b>Leeward</b> , côté sous le vent                   |
| <b>Hull</b> , corps, coque d'un navire             | <b>Leeway</b> , dérive                               |
| <b>Hydraulic press</b> , presse hydraulique        | <b>Life buoy</b> , bouée de sauvetage                |
| <b>Intercostal</b> , entre les côtes               | <b>Lighter</b> , allège, barque                      |
| <b>Iron</b> , fer                                  | <b>Limber hole</b> , anguiller                       |
| <b>Iron frame</b> , couple en fer                  | <b>Lock chamber</b> , sas à écluse                   |
| <b>Iron keel</b> , quille en fer                   | <b>Lock gate</b> , porte d'écluse                    |
| <b>Iron plate</b> , tôle                           | <b>Locker</b> , équipet                              |
| <b>Iron rigging</b> , gréement en fer              | <b>Lower rigging</b> , haubans et étais des bas mâts |
| <b>Iron ship</b> , navire en fer                   | <b>Lower yards</b> , basses vergues                  |
| <b>Iron side</b> , bras de fer                     | <b>Lug sail</b> , voile de lougre                    |
| <b>Iron wire</b> , fil de fer                      | <b>Main</b> , grand                                  |
| <b>Iron work</b> , ferrure                         | <b>Main mast</b> , grand mât                         |
| <b>Jack</b> , cric, cric à vis                     | <b>Main royal mast</b> , grand mât de cacatois       |
| <b>Jaw of a boom</b> , mâchoire d'une bôme         | <b>Main royal sail</b> , grand cacatois              |
| <b>Jib</b> , foc                                   | <b>Main sail</b> , grande voile                      |
| <b>Jolly boat</b> , petit canot                    | <b>Main sheet</b> , écoute de la grande voile        |
| <b>Jump joint</b> , bout à bout                    | <b>Main shrouds</b> , grands haubans                 |
| <b>Junk</b> , jonque chinoise                      | <b>Main topgallant mast</b> , mât de grand perroquet |

## ENGLISH INTO FRENCH (continued).

|   |  |
|---|--|
| <b>Main topgallant sail</b> , grand perroquet                       | <b>Oar</b> , aviron                            |
| <b>Main topgallant staysail</b> , voile d'étai de grand perroquet   | <b>Orlop</b> , entrepont                       |
| <b>Main topmast</b> , grand mât de hune                             | <b>Orlop deck</b> , faux pont                  |
| <b>Main topmast stay</b> , étai du grand mât de hune                | <b>Outrigger</b> , aiguille de carène          |
| <b>Main topsail</b> , grand hunier                                  | <b>Paddle beam</b> , bau de force              |
| <b>Main topsail yard</b> , vergue du grand hunier                   | <b>Paddle box</b> , tambour                    |
| <b>Man-hole</b> , trou d'homme                                      | <b>Paddle float</b> , aube                     |
| <b>Man-of-war</b> , bâtiment de guerre                              | <b>Paddle wheel</b> , roue à aubes             |
| <b>Man-rope</b> , garde-corps                                       | <b>Palm</b> , patte d'ancre                    |
| <b>Marine boiler</b> , chaudière marine                             | <b>Parrel rope</b> , bâtard de racage          |
| <b>Marine engine</b> , machine à vapeur marine                      | <b>Partner</b> , étambrai                      |
| <b>Marine glue</b> , colle marine                                   | <b>Paunch</b> , natte                          |
| <b>Master shipwright</b> , premier ingénieur-constructeur d'un port | <b>Pendant</b> , flamme, banderole             |
| <b>Merchantman</b> , navire de commerce [chande                     | <b>Pig iron</b> , gueuse                       |
| <b>Merchant service</b> , marine marchande                          | <b>Pinnace</b> , pinasse, canot                |
| <b>Messenger</b> , tournevire                                       | <b>Pintle</b> , aiguillot                      |
| <b>Metacentre</b> , métacentre                                      | <b>Pitch</b> , poix, brai sec                  |
| <b>Midships</b> , milieu du navire                                  | <b>Pitch chain</b> , chaîne à la Vaucanson     |
| <b>Mizen</b> , artimon  | <b>Plank</b> , bordage, planche                |
| <b>Mizen mast</b> , mât d'artimon                                   | <b>Pole</b> , pôle, bâton                      |
| <b>Mizen sail</b> , voile d'artimon                                 | <b>Pole mast</b> , mât à pible                 |
| <b>Mizen shrouds</b> , haubans d'artimon                            | <b>Pontoon</b> , ponton de carénage            |
| <b>Mizen staysail</b> , benjamine                                   | <b>Port helm</b> , bâbord la barre             |
| <b>Mizen topgallant mast</b> , mât de perruche                      | <b>Port lid</b> , mantelet de sabord           |
| <b>Mizen topgallant staysail</b> , voile d'étai de perruche         | <b>Port sill</b> , seuillet de sabord          |
| <b>Mizen topmast staysail</b> , diabolotin                          | <b>Post</b> , poteau                           |
| <b>Moorings</b> , corps-mort  | <b>Preventer stay</b> , faux étai              |
| <b>Mould</b> , gabari   | <b>Propeller</b> , propulseur                  |
| <b>Mould loft</b> , salle des gabaris                               | <b>Propelling screw</b> , hélice propulsive    |
| <b>Mud hole</b> , trou de sel                                       | <b>Propelling screw-shaft</b> , arbre d'hélice |
| <b>Nail</b> , clou  | <b>Pulley</b> , poulie, rouleau                |
| <b>Neap tide</b> , morte-eau  | <b>Pump</b> , pompe                            |
| <b>Netting</b> , filet de bastingage                                | <b>Pump handle</b> , brinqueballe              |
| <b>Nut</b> , tenon  | <b>Punt</b> , acon, pont flottant              |
| <b>Oakum</b> , étoupe   | <b>Quadrant</b> , octant                       |
|   | <b>Quarter deck</b> , gaillard d'arrière       |
|   | <b>Quay</b> , quai                             |
|   | <b>Rabbet</b> , râblure                        |
|   | <b>Rake</b> , inclinaison                      |
|   | <b>Ratchet brace</b> , cliquet à percer        |
|   | <b>Ratline</b> , enfléchure                    |
|   | <b>Reef</b> , récif, ris                       |
|   | <b>Relieving tackles</b> , palans de carène    |



## ENGLISH INTO FRENCH (continued).

|  |   |
|--|---|
| <b>Repair</b> , radoub                       | <b>Signal flag</b> , pavillon de signal               |
| <b>Bib</b> , membre, rame                    | <b>Skin</b> , bordage                                 |
| <b>Riband</b> , lisses des couples           | <b>Skylight</b> , écoutille vitrée                    |
| <b>Big (to)</b> , gréer                      | <b>Skyscraper</b> , aile de pigeon                    |
| <b>Bigging</b> , gréement, manœuvres         | <b>Sling of a yard</b> , suspente                     |
| <b>Ring bolt</b> , cheville à boucle         | <b>Smack</b> , semaque                                |
| <b>Rivet</b> , rivet                         | <b>Sounding lead</b> , plomb de sonde                 |
| <b>Rivet (to)</b> , river                    | <b>Sounding line</b> , ligne de sonde                 |
| <b>Rolling mill</b> , laminoir               | <b>Sounding rod</b> , sonde de pompe                  |
| <b>Rope</b> , corde, cordage                 | <b>Spanker</b> , voile d'artimon                      |
| <b>Rope yarn</b> , fil de caret              | <b>Spar</b> , espar, mâtereau, montant                |
| <b>Rough-tree rail</b> , lisse de batayoles  | <b>Spar deck</b> , pont sur montant                   |
| <b>Rowlocks</b> , toletières                 | <b>Spindle</b> , tige, mèche, broche                  |
| <b>Royal mast</b> , mât de cacatois          | <b>Spirit room</b> , cale au vin                      |
| <b>Royal sail</b> , cacatois                 | <b>Spirketting</b> , feuilles bretonnes               |
| <b>Royal yard</b> , vergue de cacatois       | <b>Splice</b> , épissure                              |
| <b>Budder</b> , gouvernail                   | <b>Spoke</b> , rayon d'une roue                       |
| <b>Running rigging</b> , manœuvres courantes | <b>Sprit sail</b> , voile de civadière                |
| <b>Safety valve</b> , soupape de sûreté      | <b>Square sail</b> , voile carrée                     |
| <b>Sail</b> , voile                          | <b>Staging</b> , échafaudage                          |
| <b>Sail of a lugger</b> , bourcet            | <b>Stanchion</b> , épontille, montant                 |
| <b>Sampson's post</b> , épontille            | <b>Standard</b> , courbe, verticale                   |
| <b>Scantlings</b> , échantillons             | <b>Standing rigging</b> , manœuvres dormantes         |
| <b>Scarf</b> , écart, empâture               | <b>Stand pipe</b> , tuyau alimentaire à colonne d'eau |
| <b>Schooner</b> , goëlette                   | <b>Staple</b> , crampe de fer                         |
| <b>Screw jack</b> , vérin, cric à vis        | <b>Starboard</b> , tribord                            |
| <b>Screw propeller</b> , hélice propulsive   | <b>Starting gear</b> , mise en marche                 |
| <b>Soupper</b> , dalot                       | <b>Stay</b> , étai, relâche                           |
| <b>Scuttle</b> , écoutille, hublot           | <b>Steam engine</b> , machine à vapeur                |
| <b>Seaman</b> , matelot                      | <b>Steamer</b> , vapeur                               |
| <b>Shackle</b> , manicle                     | <b>Steam frigate</b> , frégate à vapeur               |
| <b>Shaft</b> , arbre                         | <b>Steel</b> , acier                                  |
| <b>Sheathing</b> , doublage                  | <b>Steer (to)</b> , gouverner                         |
| <b>Sheave</b> , rouet de poulie              | <b>Steering wheel</b> , roue du gouvernail            |
| <b>Sheer</b> , tonture                       | <b>Stem</b> , étrave                                  |
| <b>Sheer draught</b> , plan d'élévation      | <b>Step of the mast</b> , carlingue du mât            |
| <b>Sheer-legs</b> , bigue, chèvre            | <b>Stern</b> , poupe, arrière                         |
| <b>Sheet anchor</b> , ancre de miséricorde   | <b>Stern frame</b> , arcasse                          |
| <b>Shipwreck</b> , naufrage                  | <b>Stern post</b> , étambot                           |
| <b>Shipwright</b> , charpentier de navire    | <b>Steward's room</b> , cambuse                       |
| <b>Shrouds</b> , haubans                     | <b>Stock of an anchor</b> , jas d'ancre               |
| <b>Side scuttle</b> , hublot                 | <b>Stoke hole</b> , parquets des chauffeurs           |
|  | <b>Store room</b> , soute                             |

## ENGLISH INTO FRENCH (concluded).

, provisions  
**ge**, arrimage  
**l**, virure  
**chape**, courroie, bride  
**l anchor**, ancre de touée  
**g box**, presse-étoupe  
**g sail**, bonnette  
**g sail boom**, bout dehors  
**n pipe**, tuyau d'aspiration  
**f sails**, jeu de voile  
**faubert**  
**l**, tourniquet en fer  
**l**, palan  
**ulin**, baignolet  
**on**, fer en T  
**ope**, longue-vue  
**ale**, axiomètre  
**ate**, gabari  
**le**, cosse en fer [corne  
**t halliard**, drisse d'une  
**le valve**, papillon registre  
**rt**, banc de nage  
**marée**  
**ur**, tirant  
**am**, entrain  
**if a cable**, bitture  
**l**, barre du gouvernail  
**rope**, drosse du gouvernail  
**hammer**, martinet, mar-  
**n à bascule**  
**ge**, tonnage  
**lune** [roquet  
**llant mast**, mât de per-  
**g lift**, balancine de gui  
**ast**, mât de lune  
**ail**, hunier  
**il yard**, vergue de lune  
**rope**, grelin  
**board**, frise de l'éperon  
**om**, barre d'arcasse  
**pert**, transport  
**le trees**, barres des hunes  
**assiette**, allure, arrimage  
**l**, pomme, roue, cosse  
**ions**, tourillons  
**l**, drosse de racage  
**ail**, voile de senau

**Tubular boiler**, chaudière tubu-  
**laire**  
**Tug boat**, remorqueur  
**Tumble-home**, rentrée  
**Tun**, tonneau  
**Universal joint**, joint universel  
**Upper deck**, franc tillac  
**Upper works**, œuvres mortes  
**Uptake**, culotte  
**Vane**, girouette  
**Vangs**, palans de retenue, bras  
**de bôme**  
**Vessel**, navire, bâtiment  
**Victuals**, vivres, approvisionne-  
**ments**  
**Wake**, sillage, eaux, houache  
**Wale**, préceinte  
**Ward room**, grande chambre  
**Warp**, câblot, grelin, touée  
**Warped plank**, bordage déjeté  
**Wash boards**, fargues  
**Water line**, ligne d'eau  
**Water tank**, caisse à eau  
**Water-tight bulkhead**, cloison  
**étanche**  
**Water-tight compartment**, com-  
**partiment étanche**  
**Water-way**, gouttière  
**Wave**, vague, lame  
**Weather bow**, bossoir du vent  
**Weather braces**, bras du vent  
**Weatherly ship**, navire bon  
**boulinier**  
**Wharf**, quai  
**Wheel**, roue  
**Whelps of capstan**, flasques du  
**cabestan**  
**White lead**, blanc de céruse  
**Winch**, moulinet, virevaut  
**Windlass**, guindeau, virevaut  
**Windward**, au vent  
**Workmanship**, main-d'œuvre  
**Wreck**, naufrage  
**Yard**, vergue  
**Yard arm**, bout de vergue  
**Yarn**, fil de caret  
**Yawl**, yole, moyen canot

# VOCABULARY OF TECHNICAL TERMS USED IN SHIPBUILDING.

## FRENCH—ENGLISH.

|   |   |
|---|---|
| <b>A bord</b> , aboard                                  | <b>Arrimage</b> , stowage, trimming             |
| <b>About</b> , butt, end part                           | <b>Artimon</b> , mizen sail                     |
| <b>Aboutement</b> , scarf                               | <b>Assemblage</b> , framing, scarfing           |
| <b>Accastillage</b> , upper works                       | <b>Assiette</b> , trim                          |
| <b>Acier</b> , steel                                    | <b>Aube</b> , paddle float                      |
| <b>Acier fondu</b> , cast steel                         | <b>Aube articulée</b> , feathering<br>paddle    |
| <b>Acier poule</b> , blister steel                      | <b>Au milieu du navire</b> , amidships          |
| <b>Acon</b> , punt, flat                                | <b>Au vent</b> , windward                       |
| <b>Affût</b> , gun carriage                             | <b>Avant</b> , bow, forward                     |
| <b>A flot</b> , afloat, floating                        | <b>Avant-cale</b> , launch, slip                |
| <b>Aguinée</b> , cringle                                | <b>Avant d'un vaisseau</b> , bow of a<br>vessel |
| <b>Aiguillette</b> , lashing, laniard                   | <b>Aviron</b> , oar                             |
| <b>Aile d'hélice</b> , blade of a screw                 | <b>Axiomètre</b> , tell-tale                    |
| <b>Aile de pigeon</b> , skyscraper                      | <b>Asimut</b> , azimuth                         |
| <b>Aillure</b> , carling                                | <b>Bâbord</b> , larboard                        |
| <b>A l'arrière</b> , astern                             | <b>Bâbord la barre</b> , port the helm          |
| <b>Allège</b> , lighter, barge                          | <b>Bagnolet</b> , tarpaulin                     |
| <b>Allonge</b> , futtock                                | <b>Baille</b> , bucket                          |
| <b>Allure</b> , trim                                    | <b>Baisse</b> , ebb tide                        |
| <b>Aman</b> , halliard                                  | <b>Balancine</b> , lift                         |
| <b>Amiral</b> , admiral                                 | <b>Balancine de corne</b> , topping lift        |
| <b>Amirauté</b> , admiralty                             | <b>Balancine de gui</b> , topping lift          |
| <b>Ancre</b> , anchor                                   | <b>Balaou</b> , schooner                        |
| <b>Ancre du bossoir</b> , bower anchor                  | <b>Baleinière</b> , whale boat                  |
| <b>Ancre de miséricorde</b> , sheet<br>anchor           | <b>Banc</b> , seat                              |
| <b>Angle</b> , quoin                                    | <b>Banc de nage</b> , thwart                    |
| <b>Angle oblique</b> , bevel                            | <b>Banderole</b> , pendant                      |
| <b>Anguillers</b> , limber holes                        | <b>Barbette</b> , gunwale                       |
| <b>Aspect</b> , handspike                               | <b>Barque</b> , barque                          |
| <b>Antenne</b> , lateen yard                            | <b>Barre</b> , helm, tiller, cross-tree         |
| <b>Apestis</b> , gunwale                                | <b>Barre d'arcasse</b> , transom                |
| <b>Appareil distillatoire</b> , distilling<br>apparatus | <b>Barre de hune</b> , trestle tree             |
| <b>Approvisionnement</b> , victuals,<br>naval stores    | <b>Barre du gouvernail</b> , tiller             |
| <b>Arbre</b> , shaft, mast                              | <b>Basses vergues</b> , lower yards             |
| <b>Arbre à manivelle</b> , crank shaft                  | <b>Basse voile</b> , course                     |
| <b>Arbre d'hélice</b> , screw propeller<br>shaft        | <b>Bassin</b> , shipping, dock                  |
| <b>Arcasse</b> , stern frame                            | <b>Bâtard de racage</b> , parrel rope           |
| <b>Arc-boutant</b> , boom                               | <b>Bâtardeau</b> , coffer-dam                   |
| <b>Arrière</b> , abaft, aft, stern                      | <b>Bateau</b> , boat, craft, barge              |
|   | <b>Bateau de passage</b> , ferry boat           |
|   | <b>Bateau-porte</b> , caisson                   |

## FRENCH INTO ENGLISH (continued).

|  |  |
|--|--|
| <b>ent</b> , vessel, ship              | <b>Brisant</b> , breaker                   |
| <b>ent de guerre</b> , man-of-war      | <b>Broche</b> , spindle                    |
| <b>, head, mast, pole</b>              | <b>Bronze</b> , brass                      |
| <b>eam</b>                             | <b>Bronze de canon</b> , gun metal         |
| <b>e force</b> , paddle beam           | <b>Brûlot</b> , fire ship                  |
| <b>rière</b> , clamp                   | <b>Cabane</b> , cabin                      |
| <b>ré</b> , bowsprit                   | <b>Cabestan</b> , capstan                  |
| <b>mine</b> , mizen staysail           | <b>Cabine</b> , cabin                      |
| <b>au</b> , cradle                     | <b>Câble</b> , cable                       |
| <b>, sheer-legs</b>                    | <b>Câblot</b> , warp, painter.             |
| <b>, bitts</b>                         | <b>Cabotage</b> , coasting trade           |
| <b>as</b> , knight-heads               | <b>Cabotier</b> , coasting vessel          |
| <b>de céruse</b> , white lead          | <b>Cabrion</b> , whelp                     |
| <b>, boom</b>                          | <b>Cacatois</b> , royal sail               |
| <b>otte</b> , studding sail            | <b>Cache-adent</b> , scarf                 |
| <b>ge</b> , plank, skin                | <b>Caillebottis</b> , grating              |
| <b>ge déjeté</b> , warped plank        | <b>Caisse à eau</b> , water tank           |
| <b>ge mince</b> , deal                 | <b>Caisson</b> , chest, locker             |
| <b>ges des ponts</b> , deck planks     | <b>Cale</b> , hold                         |
| <b>à bouton</b> , deck stopper         | <b>Cale au vin</b> , spirit room           |
| <b>ir</b> , cat-head                   | <b>Calfat</b> , caulker                    |
| <b>ir du vent</b> , weather bow        | <b>Calfater</b> , to 'caulk                |
| <b>, buoy</b>                          | <b>Cambuse</b> , steward's room            |
| <b>de sauvetage</b> , life buoy        | <b>Canonnière</b> , gunboat                |
| <b>n</b> , bolt, pin                   | <b>Canot</b> , boat, yawl                  |
| <b>et</b> , sail of a lugger           | <b>Cap de mouton</b> , dead-eye            |
| <b>ole</b> , compass                   | <b>Capitaine de frégate</b> , commander    |
| <b>butt</b> , end                      | <b>Capon</b> , cat block, cat hook         |
| <b>à bout</b> , jump joint             | <b>Capot d'échelle</b> , companion         |
| <b>dehors</b> , studding-sail boom     | <b>Carène</b> , careen                     |
| <b>dehors de clinfoo</b> , flying boom | <b>Cargaison</b> , cargo                   |
| <b>de vergue</b> , yard arm            | <b>Cargue</b> , brail, garnet              |
| <b>des apôtres</b> , knight-heads      | <b>Cargues-points</b> , clew garnets       |
| <b>pitch</b>                           | <b>Carlingue</b> , keelson, engine-bearer  |
| <b>brace</b> , arm                     | <b>Carlingue du mât</b> , step of the mast |
| <b>de bôme</b> , vang                  | <b>Carré</b> , square-rigged               |
| <b>de fer</b> , iron side              | <b>Carreau</b> , gunwale of a boat         |
| <b>du petit hunier</b> , fore topsail  | <b>Caveau</b> , store room                 |
| <b>ces</b>                             | <b>Chaîne</b> , chain                      |
| <b>du vent</b> , weather braces        | <b>Chaîne à la Vaucanson</b> , pitch chain |
| <b>e</b> , fathom                      | <b>Chaîne sans fin</b> , endless chain     |
| <b>, strap</b>                         | <b>Chambre</b> , cabin                     |
| <b>brig</b>                            | <b>Chambre de la machine</b> , engine room |
| <b>ntin</b> , brigantine               | <b>Chanvre</b> , hemp                      |
| <b>ntine</b> , spanker, driver         |  |
| <b>ueballe</b> , pump handle           |  |

## FRENCH INTO ENGLISH (continued).

|  |  |
|--|--|
| <b>Chargement</b> , cargo                            | <b>Côté</b> , side, broadside  |
| <b>Charpente</b> , framing                           | <b>Côté sous le vent</b> , lee side                                  |
| <b>Charpentier</b> , carpenter, shipwright           | <b>Cou de cygne</b> , goose-neck                                     |
| <b>Chaudière marine</b> , marine boiler              | <b>Couleurs</b> , ship's flag, colours                               |
| <b>Chaudière tubulaire</b> , tubular boiler          | <b>Couple</b> , frame, timber  |
| <b>Chaudronnier</b> , boiler maker                   | <b>Couple en fer</b> , iron frame                                    |
| <b>Cheval-vapeur</b> , horse power                   | <b>Couples dévoyés</b> , cant timbers                                |
| <b>Cheville</b> , bolt                               | <b>Courbaton</b> , bracket   |
| <b>Cheville à boucles</b> , ring bolt                | <b>Courbe</b> , knee, standard                                       |
| <b>Cheville à œillet</b> , eye bolt                  | <b>Couronnement</b> , taffrail                                       |
| <b>Chèvre</b> , crane, sheer-legs                    | <b>Cours</b> , strake  |
| <b>Clapet</b> , clack valve                          | <b>Crampe de fer</b> , iron staple                                   |
| <b>Clapet de décharge</b> , delivery valve           | <b>Crapaud</b> , goose-neck  |
| <b>Clinfoc</b> , flying jib                          | <b>Crapaudine</b> , bed plate  |
| <b>Cliquet à percer</b> , ratchet brace              | <b>Creux</b> , depth   |
| <b>Cloche</b> , bell                                 | <b>Creux de cale</b> , depth of hold                                 |
| <b>Cloison</b> , bulkhead                            | <b>Cric à vis</b> , screw jack                                       |
| <b>Cloison étanche</b> , water-tight bulkhead        | <b>Croiseur</b> , cruiser  |
| <b>Clou</b> , nail                                   | <b>Cuisine</b> , galley  |
| <b>Coïttes</b> , bilge ways                          | <b>Cuivre</b> , copper   |
| <b>Colle marine</b> , marine glue                    | <b>Cul</b> , poop, after part, stern                                 |
| <b>Collerette</b> , flange                           | <b>Cure-môle</b> , dredging machine                                  |
| <b>Collet</b> , flange                               | <b>Cutter</b> , cutter   |
| <b>Compartment étanche</b> , water-tight compartment | <b>Dalot</b> , scupper   |
| <b>Compas de route</b> , compass                     | <b>Darse</b> , dock  |
| <b>Compas de variation</b> , azimuth compass         | <b>Davier</b> , davit  |
| <b>Comput</b> , calculation                          | <b>Débarquement</b> , unloading                                      |
| <b>Constructeur</b> , builder [post]                 | <b>Défense</b> , fender  |
| <b>Contre-étambot</b> , back of stern                | <b>Dérive</b> , leeway   |
| <b>Contre-étrave</b> , apron                         | <b>Dessin d'ensemble</b> , general drawing                           |
| <b>Coque d'un navire</b> , hull                      | <b>Diablon</b> , mizen topgallant stay-sail                          |
| <b>Cordage</b> , rope, rigging                       | <b>Diablotin</b> , mizen topmast stay-sail                           |
| <b>Corde</b> , rope                                  | <b>Doublage</b> , sheathing  |
| <b>Corne</b> , throat, peak                          | <b>Doublé en cuivre</b> , copper-bottomed                            |
| <b>Corne d'artimon</b> , gaff                        | <b>Drisse</b> , halliard   |
| <b>Cornière</b> , angle iron                         | <b>Drisse d'une corne</b> , throat halliard                          |
| <b>Corps</b> , hull                                  | <b>Drisse de la trinquette du petit foc</b> , fore staysail halliard |
| <b>Corps flottant</b> , floating body                | <b>Drisse de racage</b> , truss                                      |
| <b>Corps-mort</b> , bollards                         | <b>Drisse du gouvernail</b> , tiller rope                            |
| <b>Corvette</b> , corvette, sloop of war             | <b>Drisse du grand hunier</b> , main topsail halliard                |
| <b>Cosse</b> , truck, thimble                        |  |

## FRENCH INTO ENGLISH (continued).

|   |  |
|---|--|
| <b>le du petit perroquet</b> , fore gallant sail halliard | <b>Etai du petit hunier</b> , fore top-mast stay |
| <b>tte</b> , poop   | <b>Etai et faux</b> , fore stay                  |
| <b>;</b> , wake   | <b>Etambot</b> , stern post                      |
| <b>,</b> , ebb tide                                       | <b>Etambrai</b> , partner                        |
| <b>t</b> , scarf  | <b>Etance</b> , Sampson's post                   |
| <b>faudage</b> , staging                                  | <b>Etanche</b> , tight                           |
| <b>ntillon</b> , scantling                                | <b>Etancher</b> , to free from water             |
| <b>rpe</b> , head rail                                    | <b>Etoupe</b> , oakum                            |
| <b>lle</b> , ladder                                       | <b>Etrave</b> , stem                             |
| <b>se</b> , dock  | <b>Façons</b> , run, rising floor                |
| <b>te</b> , sheet   | <b>Fardage</b> , dunnage                         |
| <b>te de la grande voile</b> , main sail                  | <b>Fargues</b> , wash-boards                     |
| <b>æt</b>   | <b>Faubert</b> , swab                            |
| <b>tille</b> , hatchway, scuttle                          | <b>Fausse quille</b> , false keel                |
| <b>tille vitrée</b> , skylight                            | <b>Faux baux</b> , orlop beams                   |
| <b>tttoir</b> , grating                                   | <b>Faux bras</b> , preventer braces              |
| <b>cé</b> , flare, projecting                             | <b>Faux étau</b> , preventer stay                |
| <b>ation</b> , elevation                                  | <b>Faux mantelet</b> , dead-light                |
| <b>gis</b> , trestle trees                                | <b>Faux pont</b> , orlop deck                    |
| <b>rgé</b> , buoyant                                      | <b>Fer</b> , iron                                |
| <b>âture</b> , scarf                                      | <b>Fer à ruban</b> , hoop iron                   |
| <b>lanture</b> , step                                     | <b>Fer d'angle</b> , angle iron                  |
| <b>aver</b> , to mortise                                  | <b>Fer en barres</b> , bar iron                  |
| <b>uturé</b> , clinched                                   | <b>Fer en T</b> , tee iron                       |
| <b>essous</b> , after part                                | <b>Fer galvanisé</b> , galvanised iron           |
| <b>essus</b> , fore part                                  | <b>Ferrure</b> , iron work, hinge                |
| <b>chure</b> , rat line                                   | <b>Feuillard</b> , hoop iron                     |
| <b>aver</b> , to trim, to stow                            | <b>Feuilles bretonnes</b> , spirketting          |
| <b>igne</b> , flag, ensign                                | <b>Fil de caret</b> , rope yarn                  |
| <b>ait</b> , tie beam                                     | <b>Fil de fer</b> , iron wire                    |
| <b>e les côtés</b> , intercostal                          | <b>Filet</b> , netting                           |
| <b>emise</b> , carling                                    | <b>Filet de bastingage</b> , netting             |
| <b>epont</b> , between-decks, orlop deck                  | <b>Flamme</b> , pendant                          |
| <b>etoise</b> , transom, partner                          | <b>Flasques</b> , whelps cheeks                  |
| <b>on</b> , head, cutwater                                | <b>Flèche</b> , skyscraper mast, boom, prow      |
| <b>sure</b> , splice                                      | <b>Flèche-en-cul</b> , gaff, topsail             |
| <b>tille</b> , stanchion, pillar                          | <b>Flottaison</b> , water line                   |
| <b>tille</b> , Sampson's post                             | <b>Flottant</b> , afloat                         |
| <b>rre</b> , bevel, movable                               | <b>Foc</b> , jib                                 |
| <b>uare</b>   | <b>Foc d'artimon</b> , mizen staysail            |
| <b>pet</b> , locker                                       | <b>Fond</b> , bottom, hold, floor                |
| <b>rs</b> , spars   | <b>Fonte de fer</b> , cast iron                  |
| <b>,</b> , stay   | <b>Foret</b> , drill                             |
| <b>du grand mât de hune</b> , in topmast stay             | <b>Forme de radoub</b> , dry dock                |
|   | <b>Forme flottante</b> , wet dock                |

## FRENCH INTO ENGLISH (continued).

|   |   |
|---|---|
| <b>Forme sèche</b> , dry dock                     | <b>Grand mâât</b> , main mast                         |
| <b>Fort</b> , extreme breadth                     | <b>Grand mâât de cacatois</b> , main royal mast       |
| <b>Fortune</b> , fore sail, lug sail              | <b>Grand mâât de hune</b> , main topmast              |
| <b>Fosse</b> , pit, store room                    | <b>Grand mâât de perroquet</b> , main topgallant mast |
| <b>Fosse aux câbles</b> , cable tier              | <b>Grand perroquet</b> , main topgallant sail         |
| <b>Fouet</b> , laniard, lashing                   | <b>Grande chambre</b> , ward room                     |
| <b>Fourcats</b> , crutches                        | <b>Grande hune</b> , main top                         |
| <b>Fourche</b> , sheers                           | <b>Grande vergue</b> , main yard                      |
| <b>Fourneau</b> , furnace                         | <b>Grande voile</b> , main sail                       |
| <b>Fraicheur</b> , cat's-paw                      | <b>Grande voile d'étai</b> , main staysail            |
| <b>Frais</b> , breeze, wind                       | <b>Grande voûte</b> , counter                         |
| <b>Fraisure</b> , countersink                     | <b>Grands haubans</b> , main shrouds                  |
| <b>Franç tillac</b> , upper deck                  | <b>Grappin</b> , grapnel                              |
| <b>Frégate à vapeur</b> , steam frigate           | <b>Gréage</b> , rigging                               |
| <b>Frise de l'éperon</b> , trail board, frieze    | <b>Grément</b> , rigging                              |
| <b>Funé</b> , rigged                              | <b>Grément en fer</b> , iron rigging                  |
| <b>Fût</b> , cask                                 | <b>Gréer</b> , to rig                                 |
| <b>Gabari</b> , mould, template                   | <b>Grelin</b> , warp, tow rope                        |
| <b>Gabet</b> , vane                               | <b>Gros de l'eau</b> , high water                     |
| <b>Gaberd</b> , garboard strake                   | <b>Grue</b> , crane, windlass                         |
| <b>Gaffe</b> , boat hook                          | <b>Gué</b> , ferry                                    |
| <b>Gaillard d'arrière</b> , quarter deck          | <b>Guindeau</b> , windlass                            |
| <b>Gaillard d'avant</b> , forecastle              | <b>Guirlande</b> , breast hook                        |
| <b>Galhauban</b> , back stay                      | <b>Guitran</b> , pitch                                |
| <b>Gambes</b> , futtock shrouds                   | <b>Habitacle</b> , binnacle                           |
| <b>Garant</b> , fall, running                     | <b>Hale-bas</b> , down-haul                           |
| <b>Garant de la candelette</b> , fish-tackle fall | <b>Hamac</b> , hammock                                |
| <b>Garde-corps</b> , man rope                     | <b>Hampe</b> , handle                                 |
| <b>Gatte</b> , manger                             | <b>Haubans</b> , shrouds                              |
| <b>Genou</b> , knee                               | <b>Haubans et étai des bas mâts</b> , lower rigging   |
| <b>Girouette</b> , vane                           | <b>Havre</b> , harbour                                |
| <b>Gisole</b> , binnacle                          | <b>Heaume</b> , tiller                                |
| <b>Goëlette</b> , schooner                        | <b>Hélice propulsive</b> , screw propeller            |
| <b>Gond</b> , hinge                               | <b>Herminette</b> , adze                              |
| <b>Goret</b> , hog                                | <b>Hêtre</b> , beech                                  |
| <b>Gorgère</b> , cutwater                         | <b>Houache</b> , wake, track                          |
| <b>Gournable</b> , tree nail                      | <b>Hublot</b> , side scuttle                          |
| <b>Gouttière</b> , water-way                      | <b>Hune</b> , top                                     |
| <b>Gouvernail</b> , rudder, helm                  | <b>Hunier</b> , top sail                              |
| <b>Gouverner</b> , to steer                       | <b>Inclinaison</b> , rake, dip, heeling, stive        |
| <b>Grand</b> , main                               |   |
| <b>Grand cacatois</b> , main royal sail           |   |
| <b>Grand foc</b> , main topmast stay-sail         |   |
| <b>Grand hunier</b> , main topsail                |   |

## FRENCH INTO ENGLISH (continued).

taire, inventory  
 de chien, stem timber  
 ancre, anchor stock  
 voiles, suit of sails  
 à clin, lapped joint  
 à collet, flange joint  
 superposé, lapped joint  
 universel, universal joint  
 œux, cheeks, hounds  
 iron plate  
 t, ebb tide  
 awning, canopy  
 re à tribord toute, hard a-  
 arboard  
 re toute à bâbord, hard a-  
 ;  
 re toute au vent, hard a-  
 ther  
 wave  
 voir, rolling mill  
 e, launch  
 ur, breadth  
 , light, buoyant  
 ballast  
 swell, surge  
 as, strengthening pieces  
 d'eau, water line  
 de sonde, sounding line  
 lebatayoles, rough-treerail  
 de fort, extreme breadth  
 d'éperon, head rail  
 des couples, ribands  
 des façons, rising of the  
 r  
 ad, berth  
 gammoning  
 le, sprit of a shoulder of  
 ton sail  
 ut, hard a-lee  
 e-vue, telescope  
 e, lugger  
 re, limber hole  
 te, telescope  
 ne, engine  
 ne à cintrer les tôles,  
 ding press

Machine à draguer, dredging  
 machine [chine  
 Machine à percer, drilling ma-  
 Machine à vapeur marine, ma-  
 rine engine  
 Main-d'œuvre, workmanship  
 Mâchoire d'une bôme, jaw of a  
 boom  
 Maître d'équipage, boatswain  
 Manicle, shackle  
 Manivelle, handle  
 Manœuvres, rigging  
 Manœuvres courantes, running  
 rigging  
 Mantelet de sabord, port lid  
 Marbre, steering-wheel barrel  
 Marée, tide  
 Marguerite, messenger  
 Mariage, lashing  
 Marie-salope, mud barge  
 Marine marchande, merchant  
 service  
 Marsouin, stemson  
 Martinet, peak halliard  
 Martingale, bobstay  
 Mât, mast  
 Mât à pible, pole mast  
 Mât d'artimon, mizen mast  
 Mât de cacatois, royal mast  
 Mât de grand perroquet, main  
 topgallant mast  
 Mât de hune, topmast  
 Mât de misaine, fore mast  
 Mât de perroquet, topgallant  
 mast  
 Mât de perruche, mizen topgal-  
 lant mast  
 Mâtereau, small mast, spar  
 Mâteur, mast maker  
 Mèche, spindle, barrel  
 Mèche du cabestan, capstan  
 barrel  
 Métacentre, metacentre  
 Milieu du navire, midships  
 Misaine, fore sail  
 Mise en marche, starting gear  
 Mitraille, case shot



## FRENCH INTO ENGLISH (continued).

|  |  |
|--|--|
| <b>Modèle</b> , model, mould                               | <b>Papillon</b> , skyscraper                         |
| <b>Moise</b> , cross beam, cross-tree                      | <b>Papillon registre</b> , throttle valve            |
| <b>Molle mer</b> , slack water                             | <b>Paracloses</b> , limber boards                    |
| <b>Montant</b> , stanchion                                 | <b>Par le travers</b> , athwart                      |
| <b>Moque</b> , dead-eye, heart                             | <b>Parquets des chauffeurs</b> , stoke hole          |
| <b>Mortaise</b> , mortise                                  | <b>Passager</b> , passenger                          |
| <b>Morte eau</b> , neap tide                               | <b>Passeresse</b> , brail                            |
| <b>Moulage</b> , moulding                                  | <b>Patron de chaloupe</b> , cockswain                |
| <b>Moulinet</b> , winch                                    | <b>Patte</b> , palm, fluke                           |
| <b>Moulure</b> , moulding                                  | <b>Pavillon</b> , flag, colours                      |
| <b>Moustaches</b> , standing lifts                         | <b>Pavillon de détresse</b> , signal flag            |
| <b>Natte</b> , paunch                                      | <b>Pavillon de poupe</b> , ensign                    |
| <b>Naufrage</b> , shipwreck                                | <b>Payeur</b> , paymaster                            |
| <b>Nautique</b> , nautical                                 | <b>Peinture</b> , paint                              |
| <b>Naval</b> , naval                                       | <b>Pène</b> , mop                                    |
| <b>Navire</b> , vessel, ship                               | <b>Penture</b> , hinge                               |
| <b>Navire bon boulinier</b> , weatherly ship               | <b>Perpigner</b> , to set the frames                 |
| <b>Navire de commerce</b> , merchant-man                   | <b>Perroquet</b> , topgallant sail                   |
| <b>Navire en fer</b> , iron ship                           | <b>Perroquet de fougue</b> , mizen topsail           |
| <b>Nocher</b> , boatswain                                  | <b>Perruche</b> , mizen topgallant sail              |
| <b>Nœud</b> , hitch, bend, knot                            | <b>Petit</b> , fore top                              |
| <b>Noix</b> , hound  | <b>Petit foc</b> , flying jib                        |
| <b>Nolis</b> , freight                                     | <b>Petit fond d'un navire</b> , bilge of a ship      |
| <b>Nuaison</b> , steady wind                               | <b>Petit mât de cacatois</b> , fore royal mast       |
| <b>Oblique</b> , cant, slant                               | <b>Petit mât de hune</b> , fore topmast              |
| <b>Obusier</b> , howitzer                                  | <b>Petit mât de perroquet</b> , fore topgallant mast |
| <b>Octant</b> , quadrant                                   | <b>Petite brise</b> , cat's-paw                      |
| <b>Œillet</b> , eye, cringle                               | <b>Pic</b> , peak                                    |
| <b>Œuvre</b> , free-board                                  | <b>Pied</b> , shoe, forefoot, heel                   |
| <b>Œuvres mortes</b> , upper works                         | <b>Pinasse</b> , pinnace                             |
| <b>Office</b> , pantry                                     | <b>Pique d'abordage</b> , boarding pike              |
| <b>Oreille</b> , fluke                                     | <b>Plan vertical</b> , body plan                     |
| <b>Ourse</b> , vang, mizen boom                            | <b>Plaque d'écart de tôle</b> , butt cover           |
| <b>Pagaye</b> , paddle                                     | <b>Plaque de fondation</b> , foundation plate        |
| <b>Paille-en-cul</b> , driver                              | <b>Plaque de jonction</b> , butt cover               |
| <b>Paillet</b> , paunch                                    | <b>Plastrons</b> , knight-heads                      |
| <b>Paillot</b> , bread room                                | <b>Plat-bord</b> , gunwale                           |
| <b>Palan</b> , tackle, burton, halliard                    | <b>Pleine mer</b> , high water                       |
| <b>Palans de carène</b> , relieving tackles                | <b>Plus grande largeur</b> , breadth extreme         |
| <b>Palans de retenue</b> , vangs                           |  |
| <b>Palme</b> , palm  |  |
| <b>Panneau</b> , hatch cover                               |  |
| <b>Pantoire de la candelette de l'ancre</b> , fish pendant |  |

## FRENCH INTO ENGLISH (continued).

|   |  |
|---|--|
| <b>Point d'écoute</b> , clew                | <b>Ressac</b> , surf                                     |
| <b>Pompe</b> , pump                         | <b>Retenue</b> , relieving tackle                        |
| <b>Pompe à air</b> , air pump               | <b>Revers</b> , flare, hollow                            |
| <b>Pompe à bras</b> , hand pump             | <b>Ribord</b> , garboard strake                          |
| <b>Pompe alimentaire</b> , feed pump        | <b>Ride</b> , laniard                                    |
| <b>Pompe de cale</b> , bilge pump           | <b>Ris</b> , reef  |
| <b>Pont</b> , deck, stage                   | <b>Risade</b> , reefing                                  |
| <b>Pont entier</b> , flush deck             | <b>Risson</b> , grappling                                |
| <b>Pont principal</b> , weather deck        | <b>Rivet</b> , rivet                                     |
| <b>Ponton</b> , pontoon                     | <b>Rivet à tête fraisée</b> , flush rivet                |
| <b>Port</b> , burden, tonnage               | <b>Rivière</b> , river                                   |
| <b>Porte d'écluse</b> , lock gate           | <b>Robinet à quatre fins</b> , four-way cock             |
| <b>Pouillousse</b> , main staysail          | <b>Roue</b> , wheel                                      |
| <b>Poulie</b> , block, pulley               | <b>Roue à aubes</b> , paddle wheel                       |
| <b>Poutre</b> , girder                      | <b>Roue à aubes articulées</b> , feathering paddle-wheel |
| <b>Préceinte</b> , wall, rail               | <b>Roue de poulie</b> , sheave                           |
| <b>Presse-étoupe</b> , stuffing-box         | <b>Roue du gouvernail</b> , steering wheel               |
| <b>Presse hydraulique</b> , hydraulic press | <b>Rouf</b> , canopy                                     |
| <b>Presson</b> , crow-bar                   | <b>Rouleau</b> , pulley                                  |
| <b>Propulseur</b> , propeller               | <b>Royaux</b> , royal sails                              |
| <b>Proue</b> , prow, bow, head              | <b>Sabord</b> , gun port                                 |
| <b>Pyroscaphe</b> , steamer                 | <b>Sainte-barbe</b> , gun room                           |
| <b>Quai</b> , quay, wharf                   | <b>Salle</b> , loft                                      |
| <b>Quille</b> , keel                        | <b>Salle des gabaris</b> , mould loft                    |
| <b>Quille en fer</b> , iron keel            | <b>Sapin</b> , fir wood                                  |
| <b>Quintelage</b> , ballast                 | <b>Semaque</b> , smack                                   |
| <b>Raban</b> , earring, gasket              | <b>Semelle de dérive</b> , leeboard                      |
| <b>Râblure</b> , rabbet                     | <b>Seuillet de sabord</b> , port sill                    |
| <b>Racage</b> , parrel, truss               | <b>Sillage</b> , wake, steerage                          |
| <b>Radeau</b> , raft                        | <b>Sonde de pompe</b> , sounding rod                     |
| <b>Radier</b> , apron                       | <b>Soupape de sûreté</b> , safety valve                  |
| <b>Radoub</b> , repair                      | <b>Soupape du navire</b> , Kingston's valve              |
| <b>Ralingue</b> , bolt rope                 | <b>Sous-barbe</b> , bobstay                              |
| <b>Ralingue de chute</b> , leech rope       | <b>Soute</b> , bunker, store room                        |
| <b>Rame</b> , oar                           | <b>Soute au pain</b> , bread room                        |
| <b>Rasé</b> , dismasted                     | <b>Stabilité</b> , stability, stiffness                  |
| <b>Rayon</b> , spoke                        | <b>Suspente</b> , sling of a yard, guy, straps           |
| <b>Récif</b> , reef, ridge                  | <b>Tableau</b> , after part of a ship                    |
| <b>Reflux</b> , ebb tide                    | <b>Taille-mer</b> , cutwater                             |
| <b>Relâche</b> , stay                       | <b>Taille-vent</b> , main sail of a lugger               |
| <b>Remorqueur</b> , tug boat                | <b>Talonnaire</b> , heel of the rudder                   |
| <b>Remplissage</b> , filling piece          |  |
| <b>Renflement</b> , bluff                   |  |
| <b>Renfort</b> , lining, binding            |  |
| <b>Rentrée</b> , tumble-home                |  |
| <b>Résistance</b> , resistance              |  |

| No.  | Logarithm | No.  | Logarithm | No.  | Logarithm | No.  | Logarithm |
|------|-----------|------|-----------|------|-----------|------|-----------|
| 2.37 | .8628899  | 2.85 | 1.0473189 | 3.33 | 1.2029722 | 3.81 | 1.3376291 |
| 2.38 | .8671004  | 2.86 | 1.0508215 | 3.34 | 1.2059707 | 3.82 | 1.3402504 |
| 2.39 | .8712933  | 2.87 | 1.0543120 | 3.35 | 1.2089603 | 3.83 | 1.3428648 |
| 2.40 | .8754686  | 2.88 | 1.0577902 | 3.36 | 1.2119409 | 3.84 | 1.3454723 |
| 2.41 | .8796266  | 2.89 | 1.0612564 | 3.37 | 1.2149127 | 3.85 | 1.3480731 |
| 2.42 | .8837675  | 2.90 | 1.0647107 | 3.38 | 1.2178757 | 3.86 | 1.3506671 |
| 2.43 | .8878912  | 2.91 | 1.0681529 | 3.39 | 1.2208299 | 3.87 | 1.3532544 |
| 2.44 | .8919980  | 2.92 | 1.0715836 | 3.40 | 1.2237754 | 3.88 | 1.3558351 |
| 2.45 | .8960879  | 2.93 | 1.0750024 | 3.41 | 1.2267122 | 3.89 | 1.3584091 |
| 2.46 | .9001613  | 2.94 | 1.0784095 | 3.42 | 1.2296405 | 3.90 | 1.3609765 |
| 2.47 | .9042181  | 2.95 | 1.0818051 | 3.43 | 1.2325605 | 3.91 | 1.3635373 |
| 2.48 | .9082585  | 2.96 | 1.0851892 | 3.44 | 1.2354714 | 3.92 | 1.3660916 |
| 2.49 | .9122826  | 2.97 | 1.0885619 | 3.45 | 1.2383742 | 3.93 | 1.3686395 |
| 2.50 | .9162907  | 2.98 | 1.0919233 | 3.46 | 1.2412685 | 3.94 | 1.3711807 |
| 2.51 | .9202825  | 2.99 | 1.0952733 | 3.47 | 1.2441545 | 3.95 | 1.3737156 |
| 2.52 | .9242589  | 3.00 | 1.0986124 | 3.48 | 1.2470322 | 3.96 | 1.3762440 |
| 2.53 | .9282193  | 3.01 | 1.1019400 | 3.49 | 1.2499017 | 3.97 | 1.3787661 |
| 2.54 | .9321640  | 3.02 | 1.1052568 | 3.50 | 1.2527629 | 3.98 | 1.3812818 |
| 2.55 | .9360934  | 3.03 | 1.1085626 | 3.51 | 1.2556160 | 3.99 | 1.3837911 |
| 2.56 | .9400072  | 3.04 | 1.1118575 | 3.52 | 1.2584609 | 4.00 | 1.3862943 |
| 2.57 | .9439058  | 3.05 | 1.1151415 | 3.53 | 1.2612978 | 4.01 | 1.3887912 |
| 2.58 | .9477893  | 3.06 | 1.1184147 | 3.54 | 1.2641266 | 4.02 | 1.3912818 |
| 2.59 | .9516578  | 3.07 | 1.1216775 | 3.55 | 1.2669475 | 4.03 | 1.3937763 |
| 2.60 | .9555112  | 3.08 | 1.1249295 | 3.56 | 1.2697605 | 4.04 | 1.3962446 |
| 2.61 | .9593502  | 3.09 | 1.1281710 | 3.57 | 1.2725655 | 4.05 | 1.3987168 |
| 2.62 | .9631743  | 3.10 | 1.1314021 | 3.58 | 1.2753627 | 4.06 | 1.4011829 |
| 2.63 | .9669838  | 3.11 | 1.1346227 | 3.59 | 1.2781521 | 4.07 | 1.4036429 |
| 2.64 | .9707789  | 3.12 | 1.1378330 | 3.60 | 1.2809338 | 4.08 | 1.4060969 |
| 2.65 | .9745596  | 3.13 | 1.1410330 | 3.61 | 1.2837077 | 4.09 | 1.4085449 |
| 2.66 | .9783259  | 3.14 | 1.1442227 | 3.62 | 1.2864740 | 4.10 | 1.4109869 |
| 2.67 | .9820784  | 3.15 | 1.1474024 | 3.63 | 1.2892326 | 4.11 | 1.4134230 |
| 2.68 | .9858167  | 3.16 | 1.1505718 | 3.64 | 1.2919836 | 4.12 | 1.4158531 |
| 2.69 | .9895411  | 3.17 | 1.1537315 | 3.65 | 1.2947271 | 4.13 | 1.4182774 |
| 2.70 | .9932518  | 3.18 | 1.1568811 | 3.66 | 1.2974631 | 4.14 | 1.4206957 |
| 2.71 | .9969486  | 3.19 | 1.1600209 | 3.67 | 1.3001916 | 4.15 | 1.4231083 |
| 2.72 | 1.0006318 | 3.20 | 1.1631508 | 3.68 | 1.3029127 | 4.16 | 1.4255150 |
| 2.73 | 1.0043015 | 3.21 | 1.1662708 | 3.69 | 1.3056264 | 4.17 | 1.4279161 |
| 2.74 | 1.0079579 | 3.22 | 1.1693813 | 3.70 | 1.3083328 | 4.18 | 1.4303112 |
| 2.75 | 1.0116009 | 3.23 | 1.1724821 | 3.71 | 1.3110318 | 4.19 | 1.4327007 |
| 2.76 | 1.0152306 | 3.24 | 1.1755733 | 3.72 | 1.3137236 | 4.20 | 1.4350844 |
| 2.77 | 1.0188473 | 3.25 | 1.1786549 | 3.73 | 1.3164082 | 4.21 | 1.4374626 |
| 2.78 | 1.0224509 | 3.26 | 1.1817271 | 3.74 | 1.3190856 | 4.22 | 1.4398351 |
| 2.79 | 1.0260415 | 3.27 | 1.1847899 | 3.75 | 1.3217559 | 4.23 | 1.4422020 |
| 2.80 | 1.0296193 | 3.28 | 1.1878434 | 3.76 | 1.3244189 | 4.24 | 1.4445632 |
| 2.81 | 1.0331843 | 3.29 | 1.1908875 | 3.77 | 1.3270749 | 4.25 | 1.4469189 |
| 2.82 | 1.0367368 | 3.30 | 1.1939224 | 3.78 | 1.3297240 | 4.26 | 1.4492691 |
| 2.83 | 1.0402766 | 3.31 | 1.1969481 | 3.79 | 1.3323660 | 4.27 | 1.4516138 |
| 2.84 | 1.0438040 | 3.32 | 1.1999647 | 3.80 | 1.3350010 | 4.28 | 1.4539530 |

| No.  | Logarithm | No.  | Logarithm | No.  | Logarithm | No.  | Logarithm |
|------|-----------|------|-----------|------|-----------|------|-----------|
| 4.29 | 1.4562867 | 4.77 | 1.5623462 | 5.25 | 1.6582280 | 5.73 | 1.7457155 |
| 4.30 | 1.4586149 | 4.78 | 1.5644405 | 5.26 | 1.6601310 | 5.74 | 1.7474591 |
| 4.31 | 1.4609379 | 4.79 | 1.5665304 | 5.27 | 1.6620303 | 5.75 | 1.7491998 |
| 4.32 | 1.4632553 | 4.80 | 1.5686159 | 5.28 | 1.6639260 | 5.76 | 1.7509374 |
| 4.33 | 1.4655675 | 4.81 | 1.5706971 | 5.29 | 1.6658182 | 5.77 | 1.7526720 |
| 4.34 | 1.4678743 | 4.82 | 1.5727739 | 5.30 | 1.6677068 | 5.78 | 1.7544036 |
| 4.35 | 1.4701758 | 4.83 | 1.5748464 | 5.31 | 1.6695918 | 5.79 | 1.7561323 |
| 4.36 | 1.4724720 | 4.84 | 1.5769147 | 5.32 | 1.6714733 | 5.80 | 1.7578579 |
| 4.37 | 1.4747630 | 4.85 | 1.5789787 | 5.33 | 1.6733512 | 5.81 | 1.7595805 |
| 4.38 | 1.4770487 | 4.86 | 1.5810384 | 5.34 | 1.6752256 | 5.82 | 1.7613002 |
| 4.39 | 1.4793292 | 4.87 | 1.5830939 | 5.35 | 1.6770965 | 5.83 | 1.7630170 |
| 4.40 | 1.4816045 | 4.88 | 1.5851452 | 5.36 | 1.6789639 | 5.84 | 1.7647308 |
| 4.41 | 1.4838746 | 4.89 | 1.5871923 | 5.37 | 1.6808278 | 5.85 | 1.7664416 |
| 4.42 | 1.4861396 | 4.90 | 1.5892352 | 5.38 | 1.6826882 | 5.86 | 1.7681496 |
| 4.43 | 1.4883994 | 4.91 | 1.5912739 | 5.39 | 1.6845453 | 5.87 | 1.7698546 |
| 4.44 | 1.4906543 | 4.92 | 1.5933085 | 5.40 | 1.6863989 | 5.88 | 1.7715567 |
| 4.45 | 1.4929040 | 4.93 | 1.5953389 | 5.41 | 1.6882491 | 5.89 | 1.7732559 |
| 4.46 | 1.4951487 | 4.94 | 1.5973653 | 5.42 | 1.6900958 | 5.90 | 1.7749523 |
| 4.47 | 1.4973883 | 4.95 | 1.5993875 | 5.43 | 1.6919391 | 5.91 | 1.7768458 |
| 4.48 | 1.4996230 | 4.96 | 1.6014057 | 5.44 | 1.6937790 | 5.92 | 1.7783364 |
| 4.49 | 1.5018527 | 4.97 | 1.6034198 | 5.45 | 1.6956155 | 5.93 | 1.7800242 |
| 4.50 | 1.5040773 | 4.98 | 1.6054298 | 5.46 | 1.6974487 | 5.94 | 1.7817091 |
| 4.51 | 1.5062971 | 4.99 | 1.6074358 | 5.47 | 1.6992786 | 5.95 | 1.7833912 |
| 4.52 | 1.5085119 | 5.00 | 1.6094377 | 5.48 | 1.7011051 | 5.96 | 1.7850704 |
| 4.53 | 1.5107219 | 5.01 | 1.6114359 | 5.49 | 1.7029282 | 5.97 | 1.7867469 |
| 4.54 | 1.5129269 | 5.02 | 1.6134300 | 5.50 | 1.7047481 | 5.98 | 1.7884205 |
| 4.55 | 1.5151272 | 5.03 | 1.6154200 | 5.51 | 1.7065646 | 5.99 | 1.7900914 |
| 4.56 | 1.5173226 | 5.04 | 1.6174060 | 5.52 | 1.7083778 | 6.00 | 1.7917595 |
| 4.57 | 1.5195132 | 5.05 | 1.6193882 | 5.53 | 1.7101878 | 6.01 | 1.7934247 |
| 4.58 | 1.5216990 | 5.06 | 1.6213664 | 5.54 | 1.7119944 | 6.02 | 1.7950872 |
| 4.59 | 1.5238800 | 5.07 | 1.6233408 | 5.55 | 1.7137979 | 6.03 | 1.7967470 |
| 4.60 | 1.5260563 | 5.08 | 1.6253112 | 5.56 | 1.7155981 | 6.04 | 1.7984040 |
| 4.61 | 1.5282278 | 5.09 | 1.6272778 | 5.57 | 1.7173950 | 6.05 | 1.8000582 |
| 4.62 | 1.5303947 | 5.10 | 1.6292405 | 5.58 | 1.7191887 | 6.06 | 1.8017098 |
| 4.63 | 1.5325568 | 5.11 | 1.6311994 | 5.59 | 1.7209792 | 6.07 | 1.8033586 |
| 4.64 | 1.5347143 | 5.12 | 1.6331544 | 5.60 | 1.7227660 | 6.08 | 1.8050047 |
| 4.65 | 1.5368672 | 5.13 | 1.6351057 | 5.61 | 1.7245507 | 6.09 | 1.8066481 |
| 4.66 | 1.5390154 | 5.14 | 1.6370530 | 5.62 | 1.7263316 | 6.10 | 1.8082887 |
| 4.67 | 1.5411590 | 5.15 | 1.6389967 | 5.63 | 1.7281094 | 6.11 | 1.8099267 |
| 4.68 | 1.5432981 | 5.16 | 1.6409365 | 5.64 | 1.7298840 | 6.12 | 1.8115621 |
| 4.69 | 1.5454325 | 5.17 | 1.6428726 | 5.65 | 1.7316555 | 6.13 | 1.8131947 |
| 4.70 | 1.5475625 | 5.18 | 1.6448050 | 5.66 | 1.7334238 | 6.14 | 1.8148247 |
| 4.71 | 1.5496879 | 5.19 | 1.6467336 | 5.67 | 1.7351891 | 6.15 | 1.8164520 |
| 4.72 | 1.5518087 | 5.20 | 1.6486586 | 5.68 | 1.7369512 | 6.16 | 1.8180767 |
| 4.73 | 1.5539252 | 5.21 | 1.6505798 | 5.69 | 1.7387102 | 6.17 | 1.8196988 |
| 4.74 | 1.5560371 | 5.22 | 1.6524974 | 5.70 | 1.7404661 | 6.18 | 1.8213182 |
| 4.75 | 1.5581446 | 5.23 | 1.6544112 | 5.71 | 1.7422189 | 6.19 | 1.8229351 |
| 4.76 | 1.5602476 | 5.24 | 1.6563214 | 5.72 | 1.7439687 | 6.20 | 1.8245493 |

| No.  | Logarithm | No.  | Logarithm | No.  | Logarithm | No.  | Logarithm |
|------|-----------|------|-----------|------|-----------|------|-----------|
| 6.21 | 1.8261608 | 6.69 | 1.9006138 | 7.17 | 1.9699056 | 7.65 | 2.0347056 |
| 6.22 | 1.8277699 | 6.70 | 1.9021075 | 7.18 | 1.9712993 | 7.66 | 2.0360119 |
| 6.23 | 1.8293763 | 6.71 | 1.9035989 | 7.19 | 1.9726911 | 7.67 | 2.0373166 |
| 6.24 | 1.8309801 | 6.72 | 1.9050881 | 7.20 | 1.9740810 | 7.68 | 2.0386195 |
| 6.25 | 1.8325814 | 6.73 | 1.9065751 | 7.21 | 1.9754689 | 7.69 | 2.0399207 |
| 6.26 | 1.8341801 | 6.74 | 1.9080600 | 7.22 | 1.9768549 | 7.70 | 2.0412203 |
| 6.27 | 1.8357763 | 6.75 | 1.9095425 | 7.23 | 1.9782390 | 7.71 | 2.0425181 |
| 6.28 | 1.8373699 | 6.76 | 1.9110228 | 7.24 | 1.9796212 | 7.72 | 2.0438143 |
| 6.29 | 1.8389610 | 6.77 | 1.9125011 | 7.25 | 1.9810014 | 7.73 | 2.0451088 |
| 6.30 | 1.8405496 | 6.78 | 1.9139771 | 7.26 | 1.9823798 | 7.74 | 2.0464016 |
| 6.31 | 1.8421356 | 6.79 | 1.9154509 | 7.27 | 1.9837562 | 7.75 | 2.0476928 |
| 6.32 | 1.8437191 | 6.80 | 1.9169226 | 7.28 | 1.9851308 | 7.76 | 2.0489823 |
| 6.33 | 1.8453002 | 6.81 | 1.9183921 | 7.29 | 1.9865035 | 7.77 | 2.0502701 |
| 6.34 | 1.8468787 | 6.82 | 1.9198594 | 7.30 | 1.9878743 | 7.78 | 2.0515563 |
| 6.35 | 1.8484547 | 6.83 | 1.9213247 | 7.31 | 1.9892452 | 7.79 | 2.0528408 |
| 6.36 | 1.8500283 | 6.84 | 1.9227877 | 7.32 | 1.9906103 | 7.80 | 2.0541237 |
| 6.37 | 1.8515994 | 6.85 | 1.9242486 | 7.33 | 1.9919754 | 7.81 | 2.0554049 |
| 6.38 | 1.8531680 | 6.86 | 1.9257074 | 7.34 | 1.9933387 | 7.82 | 2.0566845 |
| 6.39 | 1.8547342 | 6.87 | 1.9271641 | 7.35 | 1.9947002 | 7.83 | 2.0579624 |
| 6.40 | 1.8562979 | 6.88 | 1.9286186 | 7.36 | 1.9960599 | 7.84 | 2.0592388 |
| 6.41 | 1.8578592 | 6.89 | 1.9300710 | 7.37 | 1.9974177 | 7.85 | 2.0605135 |
| 6.42 | 1.8594181 | 6.90 | 1.9315214 | 7.38 | 1.9987736 | 7.86 | 2.0617866 |
| 6.43 | 1.8609745 | 6.91 | 1.9329696 | 7.39 | 2.0001278 | 7.87 | 2.0630580 |
| 6.44 | 1.8625285 | 6.92 | 1.9344157 | 7.40 | 2.0014800 | 7.88 | 2.0643278 |
| 6.45 | 1.8640801 | 6.93 | 1.9358598 | 7.41 | 2.0028305 | 7.89 | 2.0655961 |
| 6.46 | 1.8656293 | 6.94 | 1.9373017 | 7.42 | 2.0041790 | 7.90 | 2.0668627 |
| 6.47 | 1.8671761 | 6.95 | 1.9387416 | 7.43 | 2.0055258 | 7.91 | 2.0681277 |
| 6.48 | 1.8687205 | 6.96 | 1.9401794 | 7.44 | 2.0068708 | 7.92 | 2.0693911 |
| 6.49 | 1.8702625 | 6.97 | 1.9416152 | 7.45 | 2.0082140 | 7.93 | 2.0706530 |
| 6.50 | 1.8718021 | 6.98 | 1.9430489 | 7.46 | 2.0095553 | 7.94 | 2.0719132 |
| 6.51 | 1.8733394 | 6.99 | 1.9444805 | 7.47 | 2.0108949 | 7.95 | 2.0731719 |
| 6.52 | 1.8748743 | 7.00 | 1.9459099 | 7.48 | 2.0122327 | 7.96 | 2.0744290 |
| 6.53 | 1.8764069 | 7.01 | 1.9473376 | 7.49 | 2.0135687 | 7.97 | 2.0756845 |
| 6.54 | 1.8779371 | 7.02 | 1.9487632 | 7.50 | 2.0149030 | 7.98 | 2.0769384 |
| 6.55 | 1.8794650 | 7.03 | 1.9501866 | 7.51 | 2.0162354 | 7.99 | 2.0781907 |
| 6.56 | 1.8809906 | 7.04 | 1.9516080 | 7.52 | 2.0175661 | 8.00 | 2.0794414 |
| 6.57 | 1.8825138 | 7.05 | 1.9530275 | 7.53 | 2.0188950 | 8.01 | 2.0806907 |
| 6.58 | 1.8840347 | 7.06 | 1.9544449 | 7.54 | 2.0202221 | 8.02 | 2.0819384 |
| 6.59 | 1.8855533 | 7.07 | 1.9558604 | 7.55 | 2.0215475 | 8.03 | 2.0831845 |
| 6.60 | 1.8870697 | 7.08 | 1.9572739 | 7.56 | 2.0228711 | 8.04 | 2.0844290 |
| 6.61 | 1.8885837 | 7.09 | 1.9586853 | 7.57 | 2.0241929 | 8.05 | 2.0856720 |
| 6.62 | 1.8900954 | 7.10 | 1.9600947 | 7.58 | 2.0255131 | 8.06 | 2.0869135 |
| 6.63 | 1.8916048 | 7.11 | 1.9615022 | 7.59 | 2.0268315 | 8.07 | 2.0881534 |
| 6.64 | 1.8931119 | 7.12 | 1.9629077 | 7.60 | 2.0281482 | 8.08 | 2.0893918 |
| 6.65 | 1.8946168 | 7.13 | 1.9643112 | 7.61 | 2.0294631 | 8.09 | 2.0906287 |
| 6.66 | 1.8961194 | 7.14 | 1.9657127 | 7.62 | 2.0307763 | 8.10 | 2.0918640 |
| 6.67 | 1.8976198 | 7.15 | 1.9671123 | 7.63 | 2.0320878 | 8.11 | 2.0930984 |
| 6.68 | 1.8991179 | 7.16 | 1.9685099 | 7.64 | 2.0333976 | 8.12 | 2.0943306 |

| No.  | Logarithm | No.  | Logarithm | No.  | Logarithm | No.   | Logarithm |
|------|-----------|------|-----------|------|-----------|-------|-----------|
| 8-13 | 2-0953613 | 8-61 | 2-1529243 | 9-09 | 2-2071748 | 9-57  | 2-2586132 |
| 8-14 | 2-0967705 | 8-62 | 2-1540851 | 9-10 | 2-2082744 | 9-58  | 2-2596776 |
| 8-15 | 2-0980182 | 8-63 | 2-1552445 | 9-11 | 2-2093727 | 9-59  | 2-2607209 |
| 8-16 | 2-0992444 | 8-64 | 2-1564026 | 9-12 | 2-2104697 | 9-60  | 2-2617631 |
| 8-17 | 2-1004691 | 8-65 | 2-1575693 | 9-13 | 2-2115656 | 9-61  | 2-2628042 |
| 8-18 | 2-1016923 | 8-66 | 2-1587147 | 9-14 | 2-2126603 | 9-62  | 2-2638442 |
| 8-19 | 2-1029140 | 8-67 | 2-1598687 | 9-15 | 2-2137538 | 9-63  | 2-2648832 |
| 8-20 | 2-1041341 | 8-68 | 2-1610215 | 9-16 | 2-2148462 | 9-64  | 2-2659211 |
| 8-21 | 2-1053529 | 8-69 | 2-1621729 | 9-17 | 2-2159372 | 9-65  | 2-2669579 |
| 8-22 | 2-1065702 | 8-70 | 2-1633230 | 9-18 | 2-2170272 | 9-66  | 2-2679936 |
| 8-23 | 2-1077861 | 8-71 | 2-1644718 | 9-19 | 2-2181160 | 9-67  | 2-2690282 |
| 8-24 | 2-1089998 | 8-72 | 2-1656192 | 9-20 | 2-2192034 | 9-68  | 2-2700618 |
| 8-25 | 2-1102128 | 8-73 | 2-1667653 | 9-21 | 2-2202898 | 9-69  | 2-2710944 |
| 8-26 | 2-1114243 | 8-74 | 2-1679101 | 9-22 | 2-2213750 | 9-70  | 2-2721258 |
| 8-27 | 2-1126343 | 8-75 | 2-1690536 | 9-23 | 2-2224580 | 9-71  | 2-2731562 |
| 8-28 | 2-1138428 | 8-76 | 2-1701959 | 9-24 | 2-2235418 | 9-72  | 2-2741856 |
| 8-29 | 2-1150499 | 8-77 | 2-1713367 | 9-25 | 2-2246243 | 9-73  | 2-2752139 |
| 8-30 | 2-1162553 | 8-78 | 2-1724763 | 9-26 | 2-2257040 | 9-74  | 2-2762411 |
| 8-31 | 2-1174696 | 8-79 | 2-1736146 | 9-27 | 2-2267833 | 9-75  | 2-2772673 |
| 8-32 | 2-1186822 | 8-80 | 2-1747517 | 9-28 | 2-2278613 | 9-76  | 2-2782924 |
| 8-33 | 2-1198934 | 8-81 | 2-1758874 | 9-29 | 2-2289383 | 9-77  | 2-2793166 |
| 8-34 | 2-1210632 | 8-82 | 2-1770218 | 9-30 | 2-2300144 | 9-78  | 2-2803396 |
| 8-35 | 2-1222615 | 8-83 | 2-1781550 | 9-31 | 2-2310890 | 9-79  | 2-2813614 |
| 8-36 | 2-1234584 | 8-84 | 2-1792868 | 9-32 | 2-2321626 | 9-80  | 2-2823823 |
| 8-37 | 2-1246539 | 8-85 | 2-1804174 | 9-33 | 2-2332350 | 9-81  | 2-2834022 |
| 8-38 | 2-1258479 | 8-86 | 2-1815467 | 9-34 | 2-2343062 | 9-82  | 2-2844211 |
| 8-39 | 2-1270403 | 8-87 | 2-1826747 | 9-35 | 2-2353763 | 9-83  | 2-2854389 |
| 8-40 | 2-1282317 | 8-88 | 2-1838015 | 9-36 | 2-2364452 | 9-84  | 2-2864556 |
| 8-41 | 2-1294214 | 8-89 | 2-1849270 | 9-37 | 2-2375130 | 9-85  | 2-2874714 |
| 8-42 | 2-1306098 | 8-90 | 2-1860512 | 9-38 | 2-2385786 | 9-86  | 2-2884861 |
| 8-43 | 2-1317967 | 8-91 | 2-1871742 | 9-39 | 2-2396432 | 9-87  | 2-2894996 |
| 8-44 | 2-1329822 | 8-92 | 2-1882959 | 9-40 | 2-2407096 | 9-88  | 2-2905124 |
| 8-45 | 2-1341664 | 8-93 | 2-1894163 | 9-41 | 2-2417729 | 9-89  | 2-2915241 |
| 8-46 | 2-1353491 | 8-94 | 2-1905355 | 9-42 | 2-2428350 | 9-90  | 2-2925347 |
| 8-47 | 2-1365304 | 8-95 | 2-1916535 | 9-43 | 2-2438960 | 9-91  | 2-2935443 |
| 8-48 | 2-1377104 | 8-96 | 2-1927702 | 9-44 | 2-2449559 | 9-92  | 2-2945529 |
| 8-49 | 2-1388889 | 8-97 | 2-1938856 | 9-45 | 2-2460147 | 9-93  | 2-2955604 |
| 8-50 | 2-1400661 | 8-98 | 2-1949998 | 9-46 | 2-2470723 | 9-94  | 2-2965670 |
| 8-51 | 2-1412419 | 8-99 | 2-1961128 | 9-47 | 2-2481288 | 9-95  | 2-2975725 |
| 8-52 | 2-1424163 | 9-00 | 2-1972245 | 9-48 | 2-2491843 | 9-96  | 2-2985770 |
| 8-53 | 2-1435893 | 9-01 | 2-1983350 | 9-49 | 2-2502386 | 9-97  | 2-2995806 |
| 8-54 | 2-1447609 | 9-02 | 2-1994443 | 9-50 | 2-2512917 | 9-98  | 2-3005831 |
| 8-55 | 2-1459312 | 9-03 | 2-2005524 | 9-51 | 2-2523438 | 9-99  | 2-3015846 |
| 8-56 | 2-1471001 | 9-04 | 2-2016591 | 9-52 | 2-2533948 | 10-00 | 2-3025851 |
| 8-57 | 2-1482676 | 9-05 | 2-2027647 | 9-53 | 2-2544446 | 11-00 | 2-3978952 |
| 8-58 | 2-1494339 | 9-06 | 2-2038691 | 9-54 | 2-2554934 | 12-00 | 2-4849065 |
| 8-59 | 2-1505987 | 9-07 | 2-2049722 | 9-55 | 2-2565411 | 13-00 | 2-5708702 |
| 8-60 | 2-1517622 | 9-08 | 2-2060741 | 9-56 | 2-2575877 | 14-00 | 2-6567853 |

[illegible]

TABLE OF INCOME, WAGES, OR EXPENSES.

| Per Year | Per Month | Per Week | Per Day | Per Year | Per Month | Per Week | Per Day  |
|----------|-----------|----------|---------|----------|-----------|----------|----------|
| £ s. d.  | £ s. d.   | £ s. d.  | £ s. d. | £ s. d.  | £ s. d.   | £ s. d.  | £ s. d.  |
| 1 0      | 0 1 8     | 0 0 4½   | 0 0 0¾  | 13 0     | 1 1 8     | 0 5 0    | 0 0 8½   |
| 1 10     | 0 2 6     | 0 0 7    | 0 0 1   | 13 13    | 1 2 9     | 0 5 3    | 0 0 9    |
| 2 0      | 0 3 4     | 0 0 9½   | 0 0 1½  | 14 0     | 1 3 4     | 0 5 4½   | 0 0 9½   |
| 2 2      | 0 3 6     | 0 0 9¾   | 0 0 1½  | 14 14    | 1 4 6     | 0 5 8    | 0 0 9¾   |
| 2 10     | 0 4 2     | 0 0 11½  | 0 0 1¾  | 15 0     | 1 5 0     | 0 5 9    | 0 0 10   |
| 3 0      | 0 5 0     | 0 1 1¾   | 0 0 2   | 15 15    | 1 6 3     | 0 6 0½   | 0 0 10½  |
| 3 3      | 0 5 3     | 0 1 2½   | 0 0 2   | 16 0     | 1 6 8     | 0 6 2    | 0 0 10½  |
| 3 10     | 0 5 10    | 0 1 4½   | 0 0 2½  | 16 16    | 1 8 0     | 0 6 5½   | 0 0 11   |
| 4 0      | 0 6 8     | 0 1 6½   | 0 0 2¾  | 17 0     | 1 8 4     | 0 6 6    | 0 0 11½  |
| 4 4      | 0 7 0     | 0 1 7½   | 0 0 2¾  | 17 17    | 1 9 9     | 0 6 10   | 0 0 11¾  |
| 4 10     | 0 7 6     | 0 1 8¾   | 0 0 3   | 18 0     | 1 10 0    | 0 6 11   | 0 0 11¾  |
| 5 0      | 0 8 4     | 0 1 11   | 0 0 3½  | 18 18    | 1 11 6    | 0 7 3    | 0 1 0½   |
| 5 5      | 0 8 9     | 0 2 0¼   | 0 0 3½  | 19 0     | 1 11 8    | 0 7 3½   | 0 1 0½   |
| 5 10     | 0 9 2     | 0 2 1½   | 0 0 3¾  | 20 0     | 1 13 4    | 0 7 8    | 0 1 1½   |
| 6 0      | 0 10 0    | 0 2 3¾   | 0 0 4   | 30 0     | 2 10 0    | 0 11 6   | 0 1 7¾   |
| 6 6      | 0 10 6    | 0 2 5    | 0 0 4¼  | 40 0     | 3 6 8     | 0 15 4½  | 0 2 2¼   |
| 6 10     | 0 10 10   | 0 2 6    | 0 0 4¼  | 50 0     | 4 3 4     | 0 19 3   | 0 2 9    |
| 7 0      | 0 11 8    | 0 2 8¼   | 0 0 4½  | 60 0     | 5 0 0     | 1 3 0¾   | 0 3 3½   |
| 7 7      | 0 12 3    | 0 2 10   | 0 0 4¾  | 70 0     | 5 16 8    | 1 6 11   | 0 3 10   |
| 7 10     | 0 12 6    | 0 2 10½  | 0 0 5   | 80 0     | 6 13 4    | 1 10 9   | 0 4 4½   |
| 8 0      | 0 13 4    | 0 3 1    | 0 0 5¼  | 90 0     | 7 10 0    | 1 14 7¼  | 0 4 11   |
| 8 8      | 0 14 0    | 0 3 2¾   | 0 0 5½  | 100 0    | 8 6 8     | 1 18 5   | 0 5 5¾   |
| 8 10     | 0 14 2    | 0 3 3¼   | 0 0 5½  | 200 0    | 16 13 4   | 3 16 11  | 0 10 11½ |
| 9 0      | 0 15 0    | 0 3 5½   | 0 0 6   | 300 0    | 25 0 0    | 5 15 4½  | 0 16 5¼  |
| 9 9      | 0 15 9    | 0 3 7½   | 0 0 6½  | 400 0    | 33 6 8    | 7 13 10  | 1 1 11   |
| 10 0     | 0 16 8    | 0 3 10   | 0 0 6½  | 500 0    | 41 13 4   | 9 12 3½  | 1 7 4¾   |
| 10 10    | 0 17 6    | 0 4 0½   | 0 0 7   | 600 0    | 50 0 0    | 11 10 9  | 1 12 10½ |
| 11 0     | 0 18 4    | 0 4 3    | 0 0 7¼  | 700 0    | 58 6 8    | 13 9 2¾  | 1 18 4¼  |
| 11 11    | 0 19 3    | 0 4 5½   | 0 0 7½  | 800 0    | 66 13 4   | 15 7 8¼  | 2 3 10   |
| 12 0     | 1 0 0     | 0 4 7½   | 0 0 8   | 900 0    | 75 0 0    | 17 6 1¾  | 2 9 3¼   |
| 12 12    | 1 1 0     | 0 4 10   | 0 0 8¼  | 1,000 0  | 83 6 8    | 19 4 7¼  | 2 14 9½  |

TABLE OF THE DECIMAL EQUIVALENTS OF PENCE AND SHILLINGS.

| Pence | Shillings | Pence | Shillings | Pence | Shillings | Pence | Shillings |
|-------|-----------|-------|-----------|-------|-----------|-------|-----------|
| ½     | ·0208333  | 8½    | ·2708333  | 6½    | ·5208333  | 9½    | ·7708333  |
| ¾     | ·0416666  | 3½    | ·2916666  | 6½    | ·5416666  | 9½    | ·7916666  |
| ¾     | ·0625000  | 8¾    | ·3125000  | 6¾    | ·5625000  | 9¾    | ·8125000  |
| 1     | ·0833333  | 4     | ·3333333  | 7     | ·5833333  | 10    | ·8333333  |
| 1½    | ·1041666  | 4½    | ·3541666  | 7½    | ·6041666  | 10½   | ·8541666  |
| 1½    | ·1250000  | 4½    | ·3750000  | 7½    | ·6250000  | 10½   | ·8750000  |
| 1¾    | ·1458333  | 4¾    | ·3958333  | 7¾    | ·6458333  | 10¾   | ·8958333  |
| 2     | ·1666666  | 5     | ·4166666  | 8     | ·6666666  | 11    | ·9166666  |
| 2½    | ·1875000  | 5½    | ·4375000  | 8½    | ·6875000  | 11½   | ·9375000  |
| 2½    | ·2083333  | 5½    | ·4583333  | 8½    | ·7083333  | 11½   | ·9583333  |
| 2¾    | ·2291666  | 5¾    | ·4791666  | 8¾    | ·7291666  | 11¾   | ·9791666  |
| 3     | ·2500000  | 6     | ·5000000  | 9     | ·7500000  | 12    | 1·0000000 |



TABLE SHOWING RATES OF DISCOUNT AT VARIOUS PERCENTAGES.

| Amount<br>of Account | £5<br>per Cent. | £7½<br>per Cent. | £10<br>per Cent. | £12½<br>per Cent. | £15<br>per Cent. | £20<br>per Cent. | £25<br>per Cent. |
|----------------------|-----------------|------------------|------------------|-------------------|------------------|------------------|------------------|
| £ s. d.              | £ s. d.         | £ s. d.          | £ s. d.          | £ s. d.           | £ s. d.          | £ s. d.          | £ s. d.          |
| 0 2 6                | 0 0 1½          | 0 0 2½           | 0 0 3            | 0 0 3½            | 0 0 4½           | 0 0 6            | 0 0 7½           |
| 0 5 0                | 0 0 3           | 0 0 4½           | 0 0 6            | 0 0 7½            | 0 0 9            | 0 0 1 0          | 0 0 1 3          |
| 0 10 0               | 0 0 6           | 0 0 9            | 0 0 1 0          | 0 0 1 3           | 0 0 1 6          | 0 0 2 0          | 0 0 2 6          |
| 0 15 0               | 0 0 9           | 0 0 1 1½         | 0 0 1 6          | 0 0 1 10½         | 0 0 2 3          | 0 0 3 0          | 0 0 3 9          |
| 1 0 0                | 0 0 1 0         | 0 0 1 6          | 0 0 2 0          | 0 0 2 6           | 0 0 3 0          | 0 0 4 0          | 0 0 5 0          |
| 1 10 0               | 0 0 1 6         | 0 0 2 3          | 0 0 3 0          | 0 0 3 9           | 0 0 4 6          | 0 0 6 0          | 0 0 7 6          |
| 1 15 0               | 0 0 1 9         | 0 0 2 7½         | 0 0 3 6          | 0 0 4 4½          | 0 0 5 3          | 0 0 7 0          | 0 0 8 9          |
| 2 0 0                | 0 0 2 0         | 0 0 3 0          | 0 0 4 0          | 0 0 5 0           | 0 0 6 0          | 0 0 8 0          | 0 0 10 0         |
| 2 10 0               | 0 0 2 6         | 0 0 3 9          | 0 0 5 0          | 0 0 6 3           | 0 0 7 6          | 0 0 10 0         | 0 0 12 6         |
| 2 15 0               | 0 0 2 9         | 0 0 4 1½         | 0 0 5 6          | 0 0 6 10½         | 0 0 8 3          | 0 0 11 0         | 0 0 13 9         |
| 3 0 0                | 0 0 3 0         | 0 0 4 6          | 0 0 6 0          | 0 0 7 6           | 0 0 9 0          | 0 0 12 0         | 0 0 15 0         |
| 3 10 0               | 0 0 3 6         | 0 0 5 3          | 0 0 7 0          | 0 0 8 9           | 0 0 10 6         | 0 0 14 0         | 0 0 17 6         |
| 3 15 0               | 0 0 3 9         | 0 0 5 7½         | 0 0 7 6          | 0 0 9 4½          | 0 0 11 3         | 0 0 15 0         | 0 0 18 9         |
| 4 0 0                | 0 0 4 0         | 0 0 6 0          | 0 0 8 0          | 0 0 10 0          | 0 0 12 0         | 0 0 16 0         | 1 0 0 0          |
| 4 10 0               | 0 0 4 6         | 0 0 6 9          | 0 0 9 0          | 0 0 11 3          | 0 0 13 6         | 0 0 18 0         | 1 0 2 6          |
| 4 15 0               | 0 0 4 9         | 0 0 7 1½         | 0 0 9 6          | 0 0 11 10½        | 0 0 14 3         | 0 0 19 0         | 1 0 3 9          |
| 5 0 0                | 0 0 5 0         | 0 0 7 6          | 0 0 10 0         | 0 0 12 6          | 0 0 15 0         | 1 0 0 0          | 1 0 5 0          |
| 5 10 0               | 0 0 5 6         | 0 0 8 3          | 0 0 11 0         | 0 0 13 9          | 0 0 16 6         | 1 0 2 0          | 1 0 7 6          |
| 5 15 0               | 0 0 5 9         | 0 0 8 7½         | 0 0 11 6         | 0 0 14 4½         | 0 0 17 3         | 1 0 3 0          | 1 0 8 9          |
| 6 0 0                | 0 0 6 0         | 0 0 9 0          | 0 0 12 0         | 0 0 15 0          | 0 0 18 0         | 1 0 4 0          | 1 0 10 0         |
| 6 10 0               | 0 0 6 6         | 0 0 9 9          | 0 0 13 0         | 0 0 16 3          | 0 0 19 6         | 1 0 6 0          | 1 0 12 6         |
| 6 15 0               | 0 0 6 9         | 0 0 10 1½        | 0 0 13 6         | 0 0 16 10½        | 1 0 0 3          | 1 0 7 0          | 1 0 13 9         |
| 7 0 0                | 0 0 7 0         | 0 0 10 6         | 0 0 14 0         | 0 0 17 6          | 1 0 1 0          | 1 0 8 0          | 1 0 15 0         |
| 7 10 0               | 0 0 7 6         | 0 0 11 3         | 0 0 15 0         | 0 0 18 9          | 1 0 2 6          | 1 0 10 0         | 1 0 17 6         |
| 8 0 0                | 0 0 8 0         | 0 0 12 0         | 0 0 16 0         | 1 0 0 0           | 1 0 4 0          | 1 0 12 0         | 2 0 0 0          |
| 8 10 0               | 0 0 8 6         | 0 0 12 9         | 0 0 17 0         | 1 0 1 3           | 1 0 5 6          | 1 0 14 0         | 2 0 2 6          |
| 9 0 0                | 0 0 9 0         | 0 0 13 6         | 0 0 18 0         | 1 0 2 6           | 1 0 7 0          | 1 0 16 0         | 2 0 5 0          |
| 9 10 0               | 0 0 9 6         | 0 0 14 3         | 0 0 19 0         | 1 0 3 9           | 1 0 8 6          | 1 0 18 0         | 2 0 7 6          |
| 10 0 0               | 0 0 10 0        | 0 0 15 0         | 1 0 0 0          | 1 0 5 0           | 1 0 10 0         | 2 0 0 0          | 2 0 10 0         |
| 10 10 0              | 0 0 10 6        | 0 0 15 9         | 1 0 1 0          | 1 0 6 3           | 1 0 11 6         | 2 0 2 0          | 2 0 12 6         |
| 11 0 0               | 0 0 11 0        | 0 0 16 6         | 1 0 2 0          | 1 0 7 6           | 1 0 13 0         | 2 0 4 0          | 2 0 15 0         |
| 11 10 0              | 0 0 11 6        | 0 0 17 3         | 1 0 3 0          | 1 0 8 9           | 1 0 14 6         | 2 0 6 0          | 2 0 17 6         |
| 12 0 0               | 0 0 12 0        | 0 0 18 0         | 1 0 4 0          | 1 0 10 0          | 1 0 16 0         | 2 0 8 0          | 3 0 0 0          |
| 12 10 0              | 0 0 12 6        | 0 0 18 9         | 1 0 5 0          | 1 0 11 3          | 1 0 17 6         | 2 0 10 0         | 3 0 2 6          |
| 13 0 0               | 0 0 13 0        | 0 0 19 6         | 1 0 6 0          | 1 0 12 6          | 1 0 19 0         | 2 0 12 0         | 3 0 5 0          |
| 13 10 0              | 0 0 13 6        | 1 0 0 3          | 1 0 7 0          | 1 0 13 9          | 2 0 0 6          | 2 0 14 0         | 3 0 7 6          |
| 14 0 0               | 0 0 14 0        | 1 0 1 0          | 1 0 8 0          | 1 0 15 0          | 2 0 2 0          | 2 0 16 0         | 3 0 10 0         |
| 14 10 0              | 0 0 14 6        | 1 0 1 9          | 1 0 9 0          | 1 0 16 3          | 2 0 3 6          | 2 0 18 0         | 3 0 12 6         |
| 15 0 0               | 0 0 15 0        | 1 0 2 6          | 1 0 10 0         | 1 0 17 6          | 2 0 5 0          | 3 0 0 0          | 3 0 15 0         |
| 20 0 0               | 1 0 0 0         | 1 10 0 0         | 2 0 0 0          | 2 10 0 0          | 3 0 0 0          | 4 0 0 0          | 5 0 0 0          |
| 30 0 0               | 1 10 0 0        | 2 5 0 0          | 3 0 0 0          | 3 15 0 0          | 4 10 0 0         | 6 0 0 0          | 7 10 0 0         |
| 40 0 0               | 2 0 0 0         | 3 0 0 0          | 4 0 0 0          | 5 0 0 0           | 6 0 0 0          | 8 0 0 0          | 10 0 0 0         |
| 50 0 0               | 2 10 0 0        | 3 15 0 0         | 5 0 0 0          | 6 5 0 0           | 7 10 0 0         | 10 0 0 0         | 12 10 0 0        |
| 60 0 0               | 3 0 0 0         | 4 10 0 0         | 6 0 0 0          | 7 10 0 0          | 8 0 0 0          | 12 0 0 0         | 15 0 0 0         |
| 70 0 0               | 3 10 0 0        | 4 25 0 0         | 7 0 0 0          | 8 15 0 0          | 10 0 0 0         | 14 0 0 0         | 17 10 0 0        |
| 80 0 0               | 4 0 0 0         | 5 0 0 0          | 8 0 0 0          | 10 0 0 0          | 12 0 0 0         | 16 0 0 0         | 20 0 0 0         |
| 90 0 0               | 4 10 0 0        | 5 15 0 0         | 9 0 0 0          | 11 5 0 0          | 13 10 0 0        | 18 0 0 0         | 22 10 0 0        |

T. W. AND TON.



### WAGES TABLE

TABLE SHOWING AMOUNT EARNED IN ANY NUMBER OF HOURS  
FROM 1 TO 54, AT ALL RATES FROM 7c. TO 15c. FOR  
A WEEK OF 54 HOURS.

[illegible]

LE SHOWING AMOUNT EARNED IN ANY NUMBER OF HOURS  
FROM 1 TO 54, AT ALL RATES FROM 16s. TO 24s. FOR  
A WEEK OF 54 HOURS.

## Rate of Wages in Shillings for a Week of 54 Hours

| 16                                     | 17      | 18      | 19      | 20      | 21      | 22      | 23      | 24      |
|--|---------|---------|---------|---------|---------|---------|---------|---------|
| Amount Earned in given Number of Hours |         |         |         |         |         |         |         |         |
| s. d. £                                | s. d. £ | s. d. £ | s. d. £ | s. d. £ | s. d. £ | s. d. £ | s. d. £ | s. d. £ |
| 0 8 0                                  | 0 8 0   | 0 8 0   | 0 8 0   | 0 8 0   | 0 8 0   | 0 8 0   | 0 8 0   | 0 8 0   |
| 0 7 0                                  | 0 7 0   | 0 7 0   | 0 7 0   | 0 7 0   | 0 7 0   | 0 7 0   | 0 7 0   | 0 7 0   |
| 0 10 0                                 | 0 11 0  | 0 11 0  | 0 11 0  | 0 11 0  | 0 11 0  | 0 11 0  | 0 11 0  | 0 11 0  |
| 1 2 0                                  | 1 3 0   | 1 3 0   | 1 3 0   | 1 3 0   | 1 3 0   | 1 3 0   | 1 3 0   | 1 3 0   |
| 1 5 0                                  | 1 7 0   | 1 7 0   | 1 7 0   | 1 7 0   | 1 7 0   | 1 7 0   | 1 7 0   | 1 7 0   |
| 1 9 0                                  | 1 10 0  | 1 10 0  | 1 10 0  | 1 10 0  | 1 10 0  | 1 10 0  | 1 10 0  | 1 10 0  |
| 2 1 0                                  | 2 2 0   | 2 2 0   | 2 2 0   | 2 2 0   | 2 2 0   | 2 2 0   | 2 2 0   | 2 2 0   |
| 2 4 0                                  | 2 6 0   | 2 6 0   | 2 6 0   | 2 6 0   | 2 6 0   | 2 6 0   | 2 6 0   | 2 6 0   |
| 2 8 0                                  | 2 10 0  | 2 10 0  | 2 10 0  | 2 10 0  | 2 10 0  | 2 10 0  | 2 10 0  | 2 10 0  |
| 2 11 0                                 | 3 1 0   | 3 1 0   | 3 1 0   | 3 1 0   | 3 1 0   | 3 1 0   | 3 1 0   | 3 1 0   |
| 3 3 0                                  | 3 5 0   | 3 5 0   | 3 5 0   | 3 5 0   | 3 5 0   | 3 5 0   | 3 5 0   | 3 5 0   |
| 3 6 0                                  | 3 9 0   | 3 9 0   | 3 9 0   | 3 9 0   | 3 9 0   | 3 9 0   | 3 9 0   | 3 9 0   |
| 3 10 0                                 | 4 1 0   | 4 1 0   | 4 1 0   | 4 1 0   | 4 1 0   | 4 1 0   | 4 1 0   | 4 1 0   |
| 4 1 0                                  | 4 5 0   | 4 5 0   | 4 5 0   | 4 5 0   | 4 5 0   | 4 5 0   | 4 5 0   | 4 5 0   |
| 4 5 0                                  | 4 8 0   | 4 8 0   | 4 8 0   | 4 8 0   | 4 8 0   | 4 8 0   | 4 8 0   | 4 8 0   |
| 4 9 0                                  | 5 0 0   | 5 0 0   | 5 0 0   | 5 0 0   | 5 0 0   | 5 0 0   | 5 0 0   | 5 0 0   |
| 5 0 0                                  | 5 4 0   | 5 4 0   | 5 4 0   | 5 4 0   | 5 4 0   | 5 4 0   | 5 4 0   | 5 4 0   |
| 5 4 0                                  | 5 8 0   | 5 8 0   | 5 8 0   | 5 8 0   | 5 8 0   | 5 8 0   | 5 8 0   | 5 8 0   |
| 5 7 0                                  | 5 11 0  | 5 11 0  | 5 11 0  | 5 11 0  | 5 11 0  | 5 11 0  | 5 11 0  | 5 11 0  |
| 5 11 0                                 | 6 1 0   | 6 1 0   | 6 1 0   | 6 1 0   | 6 1 0   | 6 1 0   | 6 1 0   | 6 1 0   |
| 6 2 0                                  | 6 5 0   | 6 5 0   | 6 5 0   | 6 5 0   | 6 5 0   | 6 5 0   | 6 5 0   | 6 5 0   |
| 6 6 0                                  | 6 9 0   | 6 9 0   | 6 9 0   | 6 9 0   | 6 9 0   | 6 9 0   | 6 9 0   | 6 9 0   |
| 6 10 0                                 | 7 1 0   | 7 1 0   | 7 1 0   | 7 1 0   | 7 1 0   | 7 1 0   | 7 1 0   | 7 1 0   |
| 6 14 0                                 | 7 5 0   | 7 5 0   | 7 5 0   | 7 5 0   | 7 5 0   | 7 5 0   | 7 5 0   | 7 5 0   |
| 6 18 0                                 | 7 9 0   | 7 9 0   | 7 9 0   | 7 9 0   | 7 9 0   | 7 9 0   | 7 9 0   | 7 9 0   |
| 7 2 0                                  | 8 1 0   | 8 1 0   | 8 1 0   | 8 1 0   | 8 1 0   | 8 1 0   | 8 1 0   | 8 1 0   |
| 7 6 0                                  | 8 5 0   | 8 5 0   | 8 5 0   | 8 5 0   | 8 5 0   | 8 5 0   | 8 5 0   | 8 5 0   |
| 7 10 0                                 | 8 9 0   | 8 9 0   | 8 9 0   | 8 9 0   | 8 9 0   | 8 9 0   | 8 9 0   | 8 9 0   |
| 7 14 0                                 | 9 1 0   | 9 1 0   | 9 1 0   | 9 1 0   | 9 1 0   | 9 1 0   | 9 1 0   | 9 1 0   |
| 7 18 0                                 | 9 5 0   | 9 5 0   | 9 5 0   | 9 5 0   | 9 5 0   | 9 5 0   | 9 5 0   | 9 5 0   |
| 8 2 0                                  | 9 9 0   | 9 9 0   | 9 9 0   | 9 9 0   | 9 9 0   | 9 9 0   | 9 9 0   | 9 9 0   |
| 8 6 0                                  | 10 1 0  | 10 1 0  | 10 1 0  | 10 1 0  | 10 1 0  | 10 1 0  | 10 1 0  | 10 1 0  |
| 8 10 0                                 | 10 5 0  | 10 5 0  | 10 5 0  | 10 5 0  | 10 5 0  | 10 5 0  | 10 5 0  | 10 5 0  |
| 8 14 0                                 | 10 9 0  | 10 9 0  | 10 9 0  | 10 9 0  | 10 9 0  | 10 9 0  | 10 9 0  | 10 9 0  |
| 8 18 0                                 | 11 1 0  | 11 1 0  | 11 1 0  | 11 1 0  | 11 1 0  | 11 1 0  | 11 1 0  | 11 1 0  |
| 9 2 0                                  | 11 5 0  | 11 5 0  | 11 5 0  | 11 5 0  | 11 5 0  | 11 5 0  | 11 5 0  | 11 5 0  |
| 9 6 0                                  | 11 9 0  | 11 9 0  | 11 9 0  | 11 9 0  | 11 9 0  | 11 9 0  | 11 9 0  | 11 9 0  |
| 9 10 0                                 | 12 1 0  | 12 1 0  | 12 1 0  | 12 1 0  | 12 1 0  | 12 1 0  | 12 1 0  | 12 1 0  |
| 9 14 0                                 | 12 5 0  | 12 5 0  | 12 5 0  | 12 5 0  | 12 5 0  | 12 5 0  | 12 5 0  | 12 5 0  |
| 9 18 0                                 | 12 9 0  | 12 9 0  | 12 9 0  | 12 9 0  | 12 9 0  | 12 9 0  | 12 9 0  | 12 9 0  |
| 10 2 0                                 | 13 1 0  | 13 1 0  | 13 1 0  | 13 1 0  | 13 1 0  | 13 1 0  | 13 1 0  | 13 1 0  |
| 10 6 0                                 | 13 5 0  | 13 5 0  | 13 5 0  | 13 5 0  | 13 5 0  | 13 5 0  | 13 5 0  | 13 5 0  |
| 10 10 0                                | 13 9 0  | 13 9 0  | 13 9 0  | 13 9 0  | 13 9 0  | 13 9 0  | 13 9 0  | 13 9 0  |
| 10 14 0                                | 14 1 0  | 14 1 0  | 14 1 0  | 14 1 0  | 14 1 0  | 14 1 0  | 14 1 0  | 14 1 0  |
| 10 18 0                                | 14 5 0  | 14 5 0  | 14 5 0  | 14 5 0  | 14 5 0  | 14 5 0  | 14 5 0  | 14 5 0  |
| 11 2 0                                 | 14 9 0  | 14 9 0  | 14 9 0  | 14 9 0  | 14 9 0  | 14 9 0  | 14 9 0  | 14 9 0  |
| 11 6 0                                 | 15 1 0  | 15 1 0  | 15 1 0  | 15 1 0  | 15 1 0  | 15 1 0  | 15 1 0  | 15 1 0  |
| 11 10 0                                | 15 5 0  | 15 5 0  | 15 5 0  | 15 5 0  | 15 5 0  | 15 5 0  | 15 5 0  | 15 5 0  |
| 11 14 0                                | 15 9 0  | 15 9 0  | 15 9 0  | 15 9 0  | 15 9 0  | 15 9 0  | 15 9 0  | 15 9 0  |
| 11 18 0                                | 16 1 0  | 16 1 0  | 16 1 0  | 16 1 0  | 16 1 0  | 16 1 0  | 16 1 0  | 16 1 0  |
| 12 2 0                                 | 16 5 0  | 16 5 0  | 16 5 0  | 16 5 0  | 16 5 0  | 16 5 0  | 16 5 0  | 16 5 0  |
| 12 6 0                                 | 16 9 0  | 16 9 0  | 16 9 0  | 16 9 0  | 16 9 0  | 16 9 0  | 16 9 0  | 16 9 0  |
| 12 10 0                                | 17 1 0  | 17 1 0  | 17 1 0  | 17 1 0  | 17 1 0  | 17 1 0  | 17 1 0  | 17 1 0  |
| 12 14 0                                | 17 5 0  | 17 5 0  | 17 5 0  | 17 5 0  | 17 5 0  | 17 5 0  | 17 5 0  | 17 5 0  |
| 12 18 0                                | 17 9 0  | 17 9 0  | 17 9 0  | 17 9 0  | 17 9 0  | 17 9 0  | 17 9 0  | 17 9 0  |
| 13 2 0                                 | 18 1 0  | 18 1 0  | 18 1 0  | 18 1 0  | 18 1 0  | 18 1 0  | 18 1 0  | 18 1 0  |
| 13 6 0                                 | 18 5 0  | 18 5 0  | 18 5 0  | 18 5 0  | 18 5 0  | 18 5 0  | 18 5 0  | 18 5 0  |
| 13 10 0                                | 18 9 0  | 18 9 0  | 18 9 0  | 18 9 0  | 18 9 0  | 18 9 0  | 18 9 0  | 18 9 0  |
| 13 14 0                                | 19 1 0  | 19 1 0  | 19 1 0  | 19 1 0  | 19 1 0  | 19 1 0  | 19 1 0  | 19 1 0  |
| 13 18 0                                | 19 5 0  | 19 5 0  | 19 5 0  | 19 5 0  | 19 5 0  | 19 5 0  | 19 5 0  | 19 5 0  |
| 14 2 0                                 | 19 9 0  | 19 9 0  | 19 9 0  | 19 9 0  | 19 9 0  | 19 9 0  | 19 9 0  | 19 9 0  |
| 14 6 0                                 | 20 1 0  | 20 1 0  | 20 1 0  | 20 1 0  | 20 1 0  | 20 1 0  | 20 1 0  | 20 1 0  |
| 14 10 0                                | 20 5 0  | 20 5 0  | 20 5 0  | 20 5 0  | 20 5 0  | 20 5 0  | 20 5 0  | 20 5 0  |
| 14 14 0                                | 20 9 0  | 20 9 0  | 20 9 0  | 20 9 0  | 20 9 0  | 20 9 0  | 20 9 0  | 20 9 0  |
| 14 18 0                                | 21 1 0  | 21 1 0  | 21 1 0  | 21 1 0  | 21 1 0  | 21 1 0  | 21 1 0  | 21 1 0  |
| 15 2 0                                 | 21 5 0  | 21 5 0  | 21 5 0  | 21 5 0  | 21 5 0  | 21 5 0  | 21 5 0  | 21 5 0  |
| 15 6 0                                 | 21 9 0  | 21 9 0  | 21 9 0  | 21 9 0  | 21 9 0  | 21 9 0  | 21 9 0  | 21 9 0  |
| 15 10 0                                | 22 1 0  | 22 1 0  | 22 1 0  | 22 1 0  | 22 1 0  | 22 1 0  | 22 1 0  | 22 1 0  |
| 15 14 0                                | 22 5 0  | 22 5 0  | 22 5 0  | 22 5 0  | 22 5 0  | 22 5 0  | 22 5 0  | 22 5 0  |
| 15 18 0                                | 22 9 0  | 22 9 0  | 22 9 0  | 22 9 0  | 22 9 0  | 22 9 0  | 22 9 0  | 22 9 0  |
| 16 2 0                                 | 23 1 0  | 23 1 0  | 23 1 0  | 23 1 0  | 23 1 0  | 23 1 0  | 23 1 0  | 23 1 0  |
| 16 6 0                                 | 23 5 0  | 23 5 0  | 23 5 0  | 23 5 0  | 23 5 0  | 23 5 0  | 23 5 0  | 23 5 0  |
| 16 10 0                                | 23 9 0  | 23 9 0  | 23 9 0  | 23 9 0  | 23 9 0  | 23 9 0  | 23 9 0  | 23 9 0  |
| 16 14 0                                | 24 1 0  | 24 1 0  | 24 1 0  | 24 1 0  | 24 1 0  | 24 1 0  | 24 1 0  | 24 1 0  |
| 16 18 0                                | 24 5 0  | 24 5 0  | 24 5 0  | 24 5 0  | 24 5 0  | 24 5 0  | 24 5 0  | 24 5 0  |

TABLE SHOWING AMOUNT EARNED IN ANY NUMBER OF HOURS  
FROM 1 TO 54, AT ALL RATES FROM 25s. TO 33s. FOR  
A WEEK OF 54 HOURS.

| Rate of Wages in Shillings for a Week of 54 Hours |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |    |    |    |  |
|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|----|----|----|--|
| 25  |    | 26 |    | 27 |    | 28 |    | 29 |    | 30 |    | 31 |    | 32 |     | 33 |    |    |  |
| Amount Earned in given Number of Hours            |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |    |    |    |  |
| No. of Hours<br>at Work                           | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s. | d. | s.  | d. | s. | d. |  |
| 1   | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   | 0  | 0  | 0  |  |
| 2   | 0  | 0  | 11 | 0  | 0  | 11 | 0  | 1  | 0  | 0  | 1  | 0  | 1  | 0  | 1   | 0  | 1  | 0  |  |
| 3   | 0  | 1  | 42 | 0  | 1  | 53 | 0  | 1  | 50 | 1  | 61 | 0  | 1  | 72 | 0   | 1  | 83 | 0  |  |
| 4   | 0  | 1  | 10 | 0  | 1  | 11 | 0  | 2  | 0  | 0  | 2  | 1  | 0  | 2  | 2   | 0  | 2  | 3  |  |
| 5   | 0  | 2  | 3  | 0  | 2  | 6  | 0  | 3  | 0  | 0  | 3  | 2  | 0  | 3  | 5   | 0  | 3  | 8  |  |
| 6   | 0  | 2  | 9  | 0  | 2  | 10 | 0  | 3  | 0  | 0  | 3  | 8  | 0  | 3  | 14  | 0  | 3  | 19 |  |
| 7   | 0  | 3  | 3  | 0  | 3  | 16 | 0  | 3  | 0  | 0  | 3  | 10 | 0  | 3  | 16  | 0  | 4  | 2  |  |
| 8   | 0  | 3  | 8  | 0  | 3  | 21 | 0  | 4  | 0  | 0  | 4  | 15 | 0  | 4  | 21  | 0  | 4  | 7  |  |
| 9   | 0  | 4  | 2  | 0  | 4  | 4  | 0  | 4  | 0  | 0  | 4  | 8  | 0  | 4  | 10  | 0  | 4  | 14 |  |
| 10  | 0  | 4  | 7  | 0  | 4  | 9  | 0  | 5  | 0  | 0  | 5  | 13 | 0  | 5  | 16  | 0  | 5  | 19 |  |
| 11  | 0  | 5  | 1  | 0  | 5  | 3  | 0  | 5  | 0  | 0  | 5  | 7  | 0  | 5  | 11  | 0  | 6  | 3  |  |
| 12  | 0  | 5  | 6  | 0  | 5  | 8  | 0  | 6  | 0  | 0  | 6  | 12 | 0  | 6  | 16  | 0  | 6  | 19 |  |
| 13  | 0  | 6  | 0  | 0  | 6  | 3  | 0  | 6  | 0  | 0  | 6  | 7  | 0  | 7  | 11  | 0  | 7  | 14 |  |
| 14  | 0  | 6  | 5  | 0  | 6  | 8  | 0  | 7  | 0  | 0  | 7  | 13 | 0  | 7  | 17  | 0  | 8  | 1  |  |
| 15  | 0  | 6  | 11 | 0  | 7  | 2  | 0  | 7  | 0  | 0  | 8  | 0  | 0  | 8  | 4   | 0  | 8  | 9  |  |
| 16  | 0  | 7  | 5  | 0  | 7  | 6  | 0  | 8  | 0  | 0  | 8  | 7  | 0  | 8  | 10  | 0  | 9  | 3  |  |
| 17  | 0  | 7  | 10 | 0  | 8  | 2  | 0  | 8  | 0  | 0  | 9  | 1  | 0  | 9  | 5   | 0  | 10 | 1  |  |
| 18  | 0  | 8  | 4  | 0  | 8  | 8  | 0  | 9  | 0  | 0  | 9  | 4  | 0  | 9  | 8   | 0  | 10 | 6  |  |
| 19  | 0  | 8  | 9  | 0  | 9  | 13 | 0  | 9  | 0  | 0  | 10 | 0  | 0  | 10 | 11  | 0  | 11 | 1  |  |
| 20  | 0  | 9  | 3  | 0  | 9  | 18 | 0  | 10 | 0  | 0  | 10 | 4  | 0  | 10 | 16  | 0  | 11 | 6  |  |
| 21  | 0  | 9  | 8  | 0  | 10 | 1  | 0  | 10 | 0  | 0  | 11 | 0  | 0  | 11 | 21  | 0  | 12 | 1  |  |
| 22  | 0  | 10 | 2  | 0  | 10 | 7  | 0  | 11 | 0  | 0  | 11 | 5  | 0  | 11 | 26  | 0  | 12 | 6  |  |
| 23  | 0  | 10 | 7  | 0  | 11 | 1  | 0  | 11 | 0  | 0  | 12 | 0  | 0  | 12 | 31  | 0  | 13 | 1  |  |
| 24  | 0  | 11 | 1  | 0  | 11 | 6  | 0  | 12 | 0  | 0  | 12 | 6  | 0  | 13 | 36  | 0  | 13 | 6  |  |
| 25  | 0  | 11 | 7  | 0  | 12 | 0  | 0  | 12 | 0  | 0  | 13 | 0  | 0  | 13 | 41  | 0  | 14 | 1  |  |
| 26  | 0  | 12 | 0  | 0  | 12 | 6  | 0  | 13 | 0  | 0  | 13 | 6  | 0  | 14 | 46  | 0  | 14 | 6  |  |
| 27  | 0  | 12 | 5  | 0  | 13 | 0  | 0  | 14 | 0  | 0  | 14 | 11 | 0  | 15 | 51  | 0  | 15 | 1  |  |
| 28  | 0  | 12 | 11 | 0  | 13 | 6  | 0  | 14 | 0  | 0  | 15 | 0  | 0  | 15 | 56  | 0  | 16 | 1  |  |
| 29  | 0  | 13 | 5  | 0  | 14 | 1  | 0  | 15 | 0  | 0  | 15 | 6  | 0  | 16 | 61  | 0  | 16 | 6  |  |
| 30  | 0  | 13 | 10 | 0  | 14 | 7  | 0  | 15 | 0  | 0  | 16 | 1  | 0  | 16 | 66  | 0  | 17 | 1  |  |
| 31  | 0  | 14 | 4  | 0  | 15 | 1  | 0  | 16 | 0  | 0  | 16 | 7  | 0  | 17 | 71  | 0  | 17 | 6  |  |
| 32  | 0  | 14 | 9  | 0  | 15 | 7  | 0  | 16 | 0  | 0  | 17 | 2  | 0  | 17 | 76  | 0  | 18 | 1  |  |
| 33  | 0  | 15 | 3  | 0  | 16 | 3  | 0  | 17 | 0  | 0  | 17 | 8  | 0  | 18 | 81  | 0  | 18 | 6  |  |
| 34  | 0  | 15 | 8  | 0  | 16 | 9  | 0  | 17 | 0  | 0  | 18 | 3  | 0  | 18 | 86  | 0  | 19 | 1  |  |
| 35  | 0  | 16 | 2  | 0  | 17 | 5  | 0  | 18 | 0  | 0  | 18 | 9  | 0  | 19 | 91  | 0  | 19 | 6  |  |
| 36  | 0  | 16 | 8  | 0  | 17 | 11 | 0  | 18 | 0  | 0  | 19 | 4  | 0  | 19 | 96  | 0  | 20 | 1  |  |
| 37  | 0  | 17 | 1  | 0  | 18 | 7  | 0  | 19 | 0  | 0  | 19 | 10 | 0  | 20 | 101 | 0  | 20 | 6  |  |
| 38  | 0  | 17 | 7  | 0  | 18 | 13 | 0  | 19 | 0  | 0  | 20 | 5  | 0  | 20 | 106 | 0  | 21 | 1  |  |
| 39  | 0  | 18 | 0  | 0  | 19 | 9  | 0  | 20 | 0  | 0  | 20 | 11 | 0  | 21 | 111 | 0  | 21 | 6  |  |
| 40  | 0  | 18 | 6  | 0  | 19 | 15 | 0  | 20 | 0  | 0  | 21 | 6  | 0  | 21 | 116 | 0  | 22 | 1  |  |
| 41  | 0  | 18 | 11 | 0  | 19 | 21 | 0  | 21 | 0  | 0  | 21 | 12 | 0  | 22 | 121 | 0  | 22 | 6  |  |
| 42  | 0  | 19 | 5  | 0  | 20 | 1  | 0  | 21 | 0  | 0  | 22 | 7  | 0  | 22 | 126 | 0  | 23 | 1  |  |
| 43  | 0  | 19 | 11 | 0  | 20 | 7  | 0  | 21 | 0  | 0  | 23 | 1  | 0  | 23 | 131 | 0  | 23 | 6  |  |
| 44  | 0  | 20 | 0  | 0  | 21 | 3  | 0  | 22 | 0  | 0  | 23 | 7  | 0  | 24 | 136 | 0  | 24 | 1  |  |
| 45  | 0  | 20 | 6  | 0  | 21 | 9  | 0  | 22 | 0  | 0  | 24 | 2  | 0  | 24 | 141 | 0  | 24 | 6  |  |
| 46  | 0  | 21 | 0  | 0  | 22 | 5  | 0  | 23 | 0  | 0  | 24 | 8  | 0  | 25 | 146 | 0  | 25 | 1  |  |
| 47  | 0  | 21 | 6  | 0  | 22 | 11 | 0  | 23 | 0  | 0  | 25 | 3  | 0  | 25 | 151 | 0  | 25 | 6  |  |
| 48  | 0  | 22 | 0  | 0  | 23 | 7  | 0  | 24 | 0  | 0  | 25 | 9  | 0  | 26 | 156 | 0  | 26 | 1  |  |
| 49  | 0  | 22 | 6  | 0  | 23 | 13 | 0  | 24 | 0  | 0  | 26 | 5  | 0  | 26 | 161 | 0  | 26 | 6  |  |
| 50  | 0  | 23 | 0  | 0  | 24 | 9  | 0  | 25 | 0  | 0  | 26 | 11 | 0  | 27 | 166 | 0  | 27 | 1  |  |
| 51  | 0  | 23 | 6  | 0  | 24 | 15 | 0  | 25 | 0  | 0  | 27 | 7  | 0  | 27 | 171 | 0  | 27 | 6  |  |
| 52  | 0  | 24 | 0  | 0  | 25 | 11 | 0  | 26 | 0  | 0  | 27 | 13 | 0  | 28 | 176 | 0  | 28 | 1  |  |
| 53  | 0  | 24 | 6  | 0  | 25 | 17 | 0  | 26 | 0  | 0  | 28 | 9  | 0  | 28 | 181 | 0  | 28 | 6  |  |
| 54  | 0  | 25 | 0  | 0  | 26 | 13 | 0  | 27 | 0  | 0  | 28 | 15 | 0  | 29 | 186 | 0  | 29 | 1  |  |

HOWING AMOUNT EARNED IN ANY NUMBER OF HOURS  
1 TO 54, AT ALL RATES FROM 34s. TO 42s. FOR  
A WEEK OF 54 HOURS.

## Rate of Wages in Shillings for a Week of 54 Hours

| 35                                     | 36                                 | 37                                  | 38                                  | 39                                  | 40                                  | 41                                  | 42                                  |
|--|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| Amount Earned in given Number of Hours |                                    |                                     |                                     |                                     |                                     |                                     |                                     |
| £ s. d.                                | £ s. d.                            | £ s. d.                             | £ s. d.                             | £ s. d.                             | £ s. d.                             | £ s. d.                             | £ s. d.                             |
| 0 0 7 <sup>3</sup> / <sub>4</sub>      | 0 0 8                              | 0 0 8 <sup>1</sup> / <sub>2</sub>   | 0 0 8 <sup>1</sup> / <sub>2</sub>   | 0 0 8 <sup>1</sup> / <sub>2</sub>   | 0 0 9                               | 0 0 9                               | 0 0 9 <sup>1</sup> / <sub>2</sub>   |
| 0 1 3 <sup>1</sup> / <sub>4</sub>      | 0 1 4                              | 0 1 4 <sup>1</sup> / <sub>2</sub>   | 0 1 5                               | 0 1 5 <sup>1</sup> / <sub>2</sub>   | 0 1 5 <sup>1</sup> / <sub>2</sub>   | 0 1 6 <sup>1</sup> / <sub>2</sub>   | 0 1 6 <sup>1</sup> / <sub>2</sub>   |
| 0 1 11 <sup>1</sup> / <sub>4</sub>     | 0 2 0                              | 0 2 0 <sup>1</sup> / <sub>2</sub>   | 0 2 1 <sup>1</sup> / <sub>2</sub>   | 0 2 2                               | 0 2 2 <sup>1</sup> / <sub>2</sub>   | 0 2 3 <sup>1</sup> / <sub>2</sub>   | 0 2 4 <sup>1</sup> / <sub>2</sub>   |
| 0 2 7 <sup>3</sup> / <sub>4</sub>      | 0 2 8                              | 0 2 9                               | 0 2 9 <sup>1</sup> / <sub>2</sub>   | 0 2 10 <sup>1</sup> / <sub>2</sub>  | 0 2 11 <sup>1</sup> / <sub>2</sub>  | 0 3 0                               | 0 3 1 <sup>1</sup> / <sub>2</sub>   |
| 0 3 3                                  | 0 3 4                              | 0 3 5                               | 0 3 6                               | 0 3 7 <sup>1</sup> / <sub>2</sub>   | 0 3 8                               | 0 3 9 <sup>1</sup> / <sub>2</sub>   | 0 3 10 <sup>1</sup> / <sub>2</sub>  |
| 0 3 10 <sup>1</sup> / <sub>2</sub>     | 0 4 0                              | 0 4 1 <sup>1</sup> / <sub>2</sub>   | 0 4 2 <sup>1</sup> / <sub>2</sub>   | 0 4 4                               | 0 4 5 <sup>1</sup> / <sub>2</sub>   | 0 4 6 <sup>1</sup> / <sub>2</sub>   | 0 4 8                               |
| 0 4 6 <sup>1</sup> / <sub>2</sub>      | 0 4 8                              | 0 4 9 <sup>1</sup> / <sub>2</sub>   | 0 4 11                              | 0 5 0 <sup>1</sup> / <sub>2</sub>   | 0 5 2 <sup>1</sup> / <sub>2</sub>   | 0 5 3 <sup>1</sup> / <sub>2</sub>   | 0 5 5 <sup>1</sup> / <sub>2</sub>   |
| 0 5 2 <sup>1</sup> / <sub>2</sub>      | 0 5 4                              | 0 5 5 <sup>1</sup> / <sub>2</sub>   | 0 5 7 <sup>1</sup> / <sub>2</sub>   | 0 5 9 <sup>1</sup> / <sub>2</sub>   | 0 5 11                              | 0 6 1                               | 0 6 2 <sup>1</sup> / <sub>2</sub>   |
| 0 5 10 <sup>1</sup> / <sub>2</sub>     | 0 6 0                              | 0 6 2                               | 0 6 4                               | 0 6 6                               | 0 6 8                               | 0 6 10                              | 0 7 0                               |
| 0 6 5 <sup>1</sup> / <sub>2</sub>      | 0 6 8                              | 0 6 10 <sup>1</sup> / <sub>2</sub>  | 0 7 0 <sup>1</sup> / <sub>2</sub>   | 0 7 2 <sup>1</sup> / <sub>2</sub>   | 0 7 5                               | 0 7 7                               | 0 7 9                               |
| 0 7 1 <sup>1</sup> / <sub>2</sub>      | 0 7 4                              | 0 7 6 <sup>1</sup> / <sub>2</sub>   | 0 7 9                               | 0 7 11 <sup>1</sup> / <sub>2</sub>  | 0 8 1 <sup>1</sup> / <sub>2</sub>   | 0 8 4 <sup>1</sup> / <sub>2</sub>   | 0 8 6 <sup>1</sup> / <sub>2</sub>   |
| 0 7 9 <sup>1</sup> / <sub>2</sub>      | 0 8 0                              | 0 8 2 <sup>1</sup> / <sub>2</sub>   | 0 8 5 <sup>1</sup> / <sub>2</sub>   | 0 8 8                               | 0 8 10 <sup>1</sup> / <sub>2</sub>  | 0 9 1 <sup>1</sup> / <sub>2</sub>   | 0 9 4 <sup>1</sup> / <sub>2</sub>   |
| 0 8 5                                  | 0 8 8                              | 0 8 11                              | 0 9 1 <sup>1</sup> / <sub>2</sub>   | 0 9 4 <sup>1</sup> / <sub>2</sub>   | 0 9 7 <sup>1</sup> / <sub>2</sub>   | 0 9 10 <sup>1</sup> / <sub>2</sub>  | 0 10 1 <sup>1</sup> / <sub>2</sub>  |
| 0 9 1                                  | 0 9 4                              | 0 9 7                               | 0 9 10 <sup>1</sup> / <sub>2</sub>  | 0 10 1 <sup>1</sup> / <sub>2</sub>  | 0 10 4 <sup>1</sup> / <sub>2</sub>  | 0 10 7 <sup>1</sup> / <sub>2</sub>  | 0 10 10 <sup>1</sup> / <sub>2</sub> |
| 0 9 8 <sup>1</sup> / <sub>2</sub>      | 0 10 0                             | 0 10 3 <sup>1</sup> / <sub>2</sub>  | 0 10 6 <sup>1</sup> / <sub>2</sub>  | 0 10 10                             | 0 11 1 <sup>1</sup> / <sub>2</sub>  | 0 11 4 <sup>1</sup> / <sub>2</sub>  | 0 11 8                              |
| 0 10 4 <sup>1</sup> / <sub>2</sub>     | 0 10 8                             | 0 10 11 <sup>1</sup> / <sub>2</sub> | 0 11 3                              | 0 11 6 <sup>1</sup> / <sub>2</sub>  | 0 11 10 <sup>1</sup> / <sub>2</sub> | 0 12 1 <sup>1</sup> / <sub>2</sub>  | 0 12 5 <sup>1</sup> / <sub>2</sub>  |
| 0 11 0 <sup>1</sup> / <sub>2</sub>     | 0 11 4                             | 0 11 7 <sup>1</sup> / <sub>2</sub>  | 0 11 11 <sup>1</sup> / <sub>2</sub> | 0 12 3 <sup>1</sup> / <sub>2</sub>  | 0 12 7                              | 0 12 11                             | 0 13 2 <sup>1</sup> / <sub>2</sub>  |
| 0 11 8                                 | 0 12 0                             | 0 12 4                              | 0 12 8                              | 0 13 0                              | 0 13 4                              | 0 13 8                              | 0 14 0                              |
| 0 12 8 <sup>1</sup> / <sub>2</sub>     | 0 12 8                             | 0 13 0 <sup>1</sup> / <sub>2</sub>  | 0 13 4 <sup>1</sup> / <sub>2</sub>  | 0 13 8 <sup>1</sup> / <sub>2</sub>  | 0 14 1                              | 0 14 5                              | 0 14 9 <sup>1</sup> / <sub>2</sub>  |
| 0 12 11 <sup>1</sup> / <sub>2</sub>    | 0 13 4                             | 0 13 8 <sup>1</sup> / <sub>2</sub>  | 0 14 1                              | 0 14 5 <sup>1</sup> / <sub>2</sub>  | 0 14 9 <sup>1</sup> / <sub>2</sub>  | 0 15 2 <sup>1</sup> / <sub>2</sub>  | 0 15 6 <sup>1</sup> / <sub>2</sub>  |
| 0 13 7 <sup>1</sup> / <sub>2</sub>     | 0 14 0                             | 0 14 4 <sup>1</sup> / <sub>2</sub>  | 0 14 9 <sup>1</sup> / <sub>2</sub>  | 0 15 2                              | 0 15 6 <sup>1</sup> / <sub>2</sub>  | 0 15 11 <sup>1</sup> / <sub>2</sub> | 0 16 4                              |
| 0 14 3                                 | 0 14 8                             | 0 15 1                              | 0 15 5 <sup>1</sup> / <sub>2</sub>  | 0 15 10 <sup>1</sup> / <sub>2</sub> | 0 16 3 <sup>1</sup> / <sub>2</sub>  | 0 16 8 <sup>1</sup> / <sub>2</sub>  | 0 17 1 <sup>1</sup> / <sub>2</sub>  |
| 0 14 11                                | 0 15 4                             | 0 15 9                              | 0 16 2 <sup>1</sup> / <sub>2</sub>  | 0 16 7 <sup>1</sup> / <sub>2</sub>  | 0 17 0 <sup>1</sup> / <sub>2</sub>  | 0 17 5 <sup>1</sup> / <sub>2</sub>  | 0 17 10 <sup>1</sup> / <sub>2</sub> |
| 0 15 6 <sup>1</sup> / <sub>2</sub>     | 0 16 0                             | 0 16 5 <sup>1</sup> / <sub>2</sub>  | 0 16 10 <sup>1</sup> / <sub>2</sub> | 0 17 4                              | 0 17 9 <sup>1</sup> / <sub>2</sub>  | 0 18 2 <sup>1</sup> / <sub>2</sub>  | 0 18 8                              |
| 0 16 2 <sup>1</sup> / <sub>2</sub>     | 0 16 8                             | 0 17 1 <sup>1</sup> / <sub>2</sub>  | 0 17 7                              | 0 18 0 <sup>1</sup> / <sub>2</sub>  | 0 18 6 <sup>1</sup> / <sub>2</sub>  | 0 18 11 <sup>1</sup> / <sub>2</sub> | 0 19 5 <sup>1</sup> / <sub>2</sub>  |
| 0 16 10 <sup>1</sup> / <sub>2</sub>    | 0 17 4                             | 0 17 9 <sup>1</sup> / <sub>2</sub>  | 0 18 3 <sup>1</sup> / <sub>2</sub>  | 0 18 9 <sup>1</sup> / <sub>2</sub>  | 0 19 3                              | 0 19 9 <sup>1</sup> / <sub>2</sub>  | 0 20 2 <sup>1</sup> / <sub>2</sub>  |
| 0 17 6                                 | 0 18 0                             | 0 18 6                              | 0 19 0                              | 0 19 6 <sup>1</sup> / <sub>2</sub>  | 0 20 0                              | 0 20 6 <sup>1</sup> / <sub>2</sub>  | 0 21 0                              |
| 0 18 12                                | 0 18 8                             | 0 19 2 <sup>1</sup> / <sub>2</sub>  | 0 19 8 <sup>1</sup> / <sub>2</sub>  | 0 20 2 <sup>1</sup> / <sub>2</sub>  | 0 20 9 <sup>1</sup> / <sub>2</sub>  | 0 21 1 <sup>1</sup> / <sub>2</sub>  | 0 21 8 <sup>1</sup> / <sub>2</sub>  |
| 0 18 9 <sup>1</sup> / <sub>2</sub>     | 0 19 4                             | 0 19 10 <sup>1</sup> / <sub>2</sub> | 0 20 5 <sup>1</sup> / <sub>2</sub>  | 0 21 1 <sup>1</sup> / <sub>2</sub>  | 0 21 8 <sup>1</sup> / <sub>2</sub>  | 0 22 0 <sup>1</sup> / <sub>2</sub>  | 0 22 6 <sup>1</sup> / <sub>2</sub>  |
| 0 19 5 <sup>1</sup> / <sub>2</sub>     | 0 20 0                             | 0 20 6 <sup>1</sup> / <sub>2</sub>  | 0 21 1 <sup>1</sup> / <sub>2</sub>  | 0 21 8 <sup>1</sup> / <sub>2</sub>  | 0 22 1 <sup>1</sup> / <sub>2</sub>  | 0 22 8 <sup>1</sup> / <sub>2</sub>  | 0 23 4 <sup>1</sup> / <sub>2</sub>  |
| 1 0 1                                  | 0 20 8 <sup>1</sup> / <sub>2</sub> | 0 21 1 <sup>1</sup> / <sub>2</sub>  | 0 21 9 <sup>1</sup> / <sub>2</sub>  | 0 22 4 <sup>1</sup> / <sub>2</sub>  | 0 22 11 <sup>1</sup> / <sub>2</sub> | 0 23 5 <sup>1</sup> / <sub>2</sub>  | 0 24 1 <sup>1</sup> / <sub>2</sub>  |
| 1 0 9                                  | 0 21 1 <sup>1</sup> / <sub>2</sub> | 0 21 11 <sup>1</sup> / <sub>2</sub> | 0 22 6 <sup>1</sup> / <sub>2</sub>  | 0 23 1 <sup>1</sup> / <sub>2</sub>  | 0 23 8 <sup>1</sup> / <sub>2</sub>  | 0 24 4 <sup>1</sup> / <sub>2</sub>  | 0 24 10 <sup>1</sup> / <sub>2</sub> |
| 1 1 4 <sup>1</sup> / <sub>2</sub>      | 0 22 0 <sup>1</sup> / <sub>2</sub> | 0 22 7 <sup>1</sup> / <sub>2</sub>  | 0 23 6 <sup>1</sup> / <sub>2</sub>  | 0 24 10 <sup>1</sup> / <sub>2</sub> | 0 24 5 <sup>1</sup> / <sub>2</sub>  | 0 25 0 <sup>1</sup> / <sub>2</sub>  | 0 25 8 <sup>1</sup> / <sub>2</sub>  |
| 1 2 0 <sup>1</sup> / <sub>2</sub>      | 0 22 8 <sup>1</sup> / <sub>2</sub> | 0 23 3 <sup>1</sup> / <sub>2</sub>  | 0 23 11 <sup>1</sup> / <sub>2</sub> | 0 24 6 <sup>1</sup> / <sub>2</sub>  | 0 25 2 <sup>1</sup> / <sub>2</sub>  | 0 25 9 <sup>1</sup> / <sub>2</sub>  | 0 26 5 <sup>1</sup> / <sub>2</sub>  |
| 1 2 8 <sup>1</sup> / <sub>2</sub>      | 0 23 4 <sup>1</sup> / <sub>2</sub> | 0 23 11 <sup>1</sup> / <sub>2</sub> | 0 24 7 <sup>1</sup> / <sub>2</sub>  | 0 25 3 <sup>1</sup> / <sub>2</sub>  | 0 25 11 <sup>1</sup> / <sub>2</sub> | 0 26 7 <sup>1</sup> / <sub>2</sub>  | 0 27 2 <sup>1</sup> / <sub>2</sub>  |
| 1 3 4 <sup>1</sup> / <sub>2</sub>      | 0 24 0 <sup>1</sup> / <sub>2</sub> | 0 24 8 <sup>1</sup> / <sub>2</sub>  | 0 25 4 <sup>1</sup> / <sub>2</sub>  | 0 26 0 <sup>1</sup> / <sub>2</sub>  | 0 26 8 <sup>1</sup> / <sub>2</sub>  | 0 27 4 <sup>1</sup> / <sub>2</sub>  | 0 28 0                              |
| 1 3 11 <sup>1</sup> / <sub>2</sub>     | 0 24 8 <sup>1</sup> / <sub>2</sub> | 0 25 4 <sup>1</sup> / <sub>2</sub>  | 0 26 0 <sup>1</sup> / <sub>2</sub>  | 0 26 8 <sup>1</sup> / <sub>2</sub>  | 0 27 5 <sup>1</sup> / <sub>2</sub>  | 0 28 1 <sup>1</sup> / <sub>2</sub>  | 0 28 9 <sup>1</sup> / <sub>2</sub>  |
| 1 4 7 <sup>1</sup> / <sub>2</sub>      | 0 25 4 <sup>1</sup> / <sub>2</sub> | 0 26 0 <sup>1</sup> / <sub>2</sub>  | 0 26 9 <sup>1</sup> / <sub>2</sub>  | 0 27 5 <sup>1</sup> / <sub>2</sub>  | 0 28 13 <sup>1</sup> / <sub>2</sub> | 0 29 10 <sup>1</sup> / <sub>2</sub> | 0 29 6 <sup>1</sup> / <sub>2</sub>  |
| 1 5 3 <sup>1</sup> / <sub>2</sub>      | 0 26 0 <sup>1</sup> / <sub>2</sub> | 0 26 8 <sup>1</sup> / <sub>2</sub>  | 0 27 5 <sup>1</sup> / <sub>2</sub>  | 0 28 2 <sup>1</sup> / <sub>2</sub>  | 0 28 10 <sup>1</sup> / <sub>2</sub> | 0 29 7 <sup>1</sup> / <sub>2</sub>  | 0 30 4 <sup>1</sup> / <sub>2</sub>  |
| 1 5 11 <sup>1</sup> / <sub>2</sub>     | 0 26 8 <sup>1</sup> / <sub>2</sub> | 0 27 5 <sup>1</sup> / <sub>2</sub>  | 0 28 1 <sup>1</sup> / <sub>2</sub>  | 0 28 10 <sup>1</sup> / <sub>2</sub> | 0 29 7 <sup>1</sup> / <sub>2</sub>  | 0 30 4 <sup>1</sup> / <sub>2</sub>  | 0 31 1 <sup>1</sup> / <sub>2</sub>  |
| 1 6 7 <sup>1</sup> / <sub>2</sub>      | 0 27 4 <sup>1</sup> / <sub>2</sub> | 0 28 1 <sup>1</sup> / <sub>2</sub>  | 0 28 10 <sup>1</sup> / <sub>2</sub> | 0 29 7 <sup>1</sup> / <sub>2</sub>  | 0 30 4 <sup>1</sup> / <sub>2</sub>  | 0 31 1 <sup>1</sup> / <sub>2</sub>  | 0 31 10 <sup>1</sup> / <sub>2</sub> |
| 1 7 2 <sup>1</sup> / <sub>2</sub>      | 0 28 0 <sup>1</sup> / <sub>2</sub> | 0 28 9 <sup>1</sup> / <sub>2</sub>  | 0 29 6 <sup>1</sup> / <sub>2</sub>  | 0 30 4 <sup>1</sup> / <sub>2</sub>  | 0 31 1 <sup>1</sup> / <sub>2</sub>  | 0 31 10 <sup>1</sup> / <sub>2</sub> | 0 32 8 <sup>1</sup> / <sub>2</sub>  |
| 1 7 10 <sup>1</sup> / <sub>2</sub>     | 0 28 8 <sup>1</sup> / <sub>2</sub> | 0 29 5 <sup>1</sup> / <sub>2</sub>  | 0 30 3 <sup>1</sup> / <sub>2</sub>  | 0 31 11 <sup>1</sup> / <sub>2</sub> | 0 32 0 <sup>1</sup> / <sub>2</sub>  | 0 32 12 <sup>1</sup> / <sub>2</sub> | 0 33 5 <sup>1</sup> / <sub>2</sub>  |
| 1 8 6 <sup>1</sup> / <sub>2</sub>      | 0 29 4 <sup>1</sup> / <sub>2</sub> | 0 30 1 <sup>1</sup> / <sub>2</sub>  | 0 31 11 <sup>1</sup> / <sub>2</sub> | 0 32 7 <sup>1</sup> / <sub>2</sub>  | 0 33 1 <sup>1</sup> / <sub>2</sub>  | 0 34 5 <sup>1</sup> / <sub>2</sub>  | 0 34 2 <sup>1</sup> / <sub>2</sub>  |
| 1 9 2 <sup>1</sup> / <sub>2</sub>      | 0 30 0 <sup>1</sup> / <sub>2</sub> | 0 30 10 <sup>1</sup> / <sub>2</sub> | 0 31 8 <sup>1</sup> / <sub>2</sub>  | 0 32 6 <sup>1</sup> / <sub>2</sub>  | 0 33 4 <sup>1</sup> / <sub>2</sub>  | 0 34 2 <sup>1</sup> / <sub>2</sub>  | 0 35 0                              |
| 1 9 9 <sup>1</sup> / <sub>2</sub>      | 0 30 8 <sup>1</sup> / <sub>2</sub> | 0 31 6 <sup>1</sup> / <sub>2</sub>  | 0 32 4 <sup>1</sup> / <sub>2</sub>  | 0 33 2 <sup>1</sup> / <sub>2</sub>  | 0 34 1 <sup>1</sup> / <sub>2</sub>  | 0 35 11 <sup>1</sup> / <sub>2</sub> | 0 35 9 <sup>1</sup> / <sub>2</sub>  |
| 1 10 5 <sup>1</sup> / <sub>2</sub>     | 0 31 4 <sup>1</sup> / <sub>2</sub> | 0 32 2 <sup>1</sup> / <sub>2</sub>  | 0 33 1 <sup>1</sup> / <sub>2</sub>  | 0 34 11 <sup>1</sup> / <sub>2</sub> | 0 35 9 <sup>1</sup> / <sub>2</sub>  | 0 36 8 <sup>1</sup> / <sub>2</sub>  | 0 36 6 <sup>1</sup> / <sub>2</sub>  |
| 1 11 1 <sup>1</sup> / <sub>2</sub>     | 0 32 0 <sup>1</sup> / <sub>2</sub> | 0 32 10 <sup>1</sup> / <sub>2</sub> | 0 33 9 <sup>1</sup> / <sub>2</sub>  | 0 34 8 <sup>1</sup> / <sub>2</sub>  | 0 35 6 <sup>1</sup> / <sub>2</sub>  | 0 36 5 <sup>1</sup> / <sub>2</sub>  | 0 37 4 <sup>1</sup> / <sub>2</sub>  |
| 1 11 9                                 | 0 32 8 <sup>1</sup> / <sub>2</sub> | 0 33 7 <sup>1</sup> / <sub>2</sub>  | 0 34 5 <sup>1</sup> / <sub>2</sub>  | 0 35 4 <sup>1</sup> / <sub>2</sub>  | 0 36 3 <sup>1</sup> / <sub>2</sub>  | 0 37 2 <sup>1</sup> / <sub>2</sub>  | 0 38 1 <sup>1</sup> / <sub>2</sub>  |
| 1 12 5                                 | 0 33 4 <sup>1</sup> / <sub>2</sub> | 0 34 3 <sup>1</sup> / <sub>2</sub>  | 0 35 2 <sup>1</sup> / <sub>2</sub>  | 0 36 1 <sup>1</sup> / <sub>2</sub>  | 0 37 0 <sup>1</sup> / <sub>2</sub>  | 0 38 11 <sup>1</sup> / <sub>2</sub> | 0 39 10 <sup>1</sup> / <sub>2</sub> |
| 1 13 0 <sup>1</sup> / <sub>2</sub>     | 0 34 0 <sup>1</sup> / <sub>2</sub> | 0 34 11 <sup>1</sup> / <sub>2</sub> | 0 35 10 <sup>1</sup> / <sub>2</sub> | 0 36 10 <sup>1</sup> / <sub>2</sub> | 0 37 9 <sup>1</sup> / <sub>2</sub>  | 0 38 8 <sup>1</sup> / <sub>2</sub>  | 0 39 8                              |
| 1 13 8 <sup>1</sup> / <sub>2</sub>     | 0 34 8 <sup>1</sup> / <sub>2</sub> | 0 35 7 <sup>1</sup> / <sub>2</sub>  | 0 36 7 <sup>1</sup> / <sub>2</sub>  | 0 37 6 <sup>1</sup> / <sub>2</sub>  | 0 38 6 <sup>1</sup> / <sub>2</sub>  | 0 39 5 <sup>1</sup> / <sub>2</sub>  | 0 40 5 <sup>1</sup> / <sub>2</sub>  |
| 1 14 4 <sup>1</sup> / <sub>2</sub>     | 0 35 4 <sup>1</sup> / <sub>2</sub> | 0 36 3 <sup>1</sup> / <sub>2</sub>  | 0 37 3 <sup>1</sup> / <sub>2</sub>  | 0 38 3 <sup>1</sup> / <sub>2</sub>  | 0 39 3 <sup>1</sup> / <sub>2</sub>  | 0 40 2 <sup>1</sup> / <sub>2</sub>  | 0 41 2 <sup>1</sup> / <sub>2</sub>  |
| 1 15 0                                 | 0 36 0 <sup>1</sup> / <sub>2</sub> | 0 37 0 <sup>1</sup> / <sub>2</sub>  | 0 38 0 <sup>1</sup> / <sub>2</sub>  | 0 39 0 <sup>1</sup> / <sub>2</sub>  | 0 40 0 <sup>1</sup> / <sub>2</sub>  | 0 41 0 <sup>1</sup> / <sub>2</sub>  | 0 42 0                              |

## TABLE OF LOGARITHMS OF NUMBERS FROM 1 TO 10000.

*Indices of Logarithms.*

The *index* of the logarithm of a number is *one less* than the number of integral figures used in expressing that number.

| Number | Logarithm | Number | Logarithm | Number | Logarithm  |
|--------|-----------|--------|-----------|--------|------------|
| 4134   | 3.6163705 | 41.34  | 1.6163705 | 4134   | -1.6163705 |
| 413.4  | 2.6163705 | 4.134  | 0.6163705 | 0.4134 | -2.6163705 |

*To Find the Logarithm of a Number.*

Find log. of 837.2468

Log. of 837.2000 = 2.9228292

Tab. diff. 519 × 468 = 243

Log. required 2.9228535

Find log. of 830465

Log. of 830400 = 5.9192873

Tab. diff. 521 × 65 = 339

Log. required 5.9193212

*To Find the Number corresponding to a given Logarithm.*

Find number of logarithm 2.9228535

Logarithm of 837.2000 = 2.9228292

243000 ÷ diff. 519 = 468

837.2468

Find number of logarithm 5.9193212

Logarithm of 830400 = 5.9192873

33900 ÷ diff. 521 = 65

830400

*To Multiply by Logarithms.*

Add together the logarithms of the factors ; the sum will be the logarithm of the product.

*To Divide by Logarithms.*

Subtract the logarithm of the divisor from that of the dividend ; the remainder will be the logarithm of the quotient.

*To Raise a Number to any Power.*

Multiply the logarithm of the number by the index of the power to which it is to be raised ; the product will be the logarithm of the required power.

*To Extract the Root of any Number.*

Divide the logarithm of the number by the index of the root which is to be extracted ; the quotient will be the logarithm of the required root.

| No. | Logarithm | No. | Logarithm | No. | Logarithm | No. | Logarithm | No. | Logarithm |
|-----|-----------|-----|-----------|-----|-----------|-----|-----------|-----|-----------|
| 1   | 0.000000  | 21  | 1.3222193 | 41  | 1.6127839 | 61  | 1.7853298 | 81  | 1.9064850 |
| 2   | 0.3010300 | 22  | 1.3424227 | 42  | 1.6232493 | 62  | 1.7923917 | 82  | 1.9138139 |
| 3   | 0.4771213 | 23  | 1.3617278 | 43  | 1.6334685 | 63  | 1.7993405 | 83  | 1.9190781 |
| 4   | 0.6020600 | 24  | 1.3802112 | 44  | 1.6434527 | 64  | 1.8061800 | 84  | 1.9242793 |
| 5   | 0.6989700 | 25  | 1.3979400 | 45  | 1.6532125 | 65  | 1.8129134 | 85  | 1.9294189 |
| 6   | 0.7781513 | 26  | 1.4149733 | 46  | 1.6627578 | 66  | 1.8195439 | 86  | 1.9344985 |
| 7   | 0.8450980 | 27  | 1.4313638 | 47  | 1.6720979 | 67  | 1.8260748 | 87  | 1.9395193 |
| 8   | 0.9030900 | 28  | 1.4471580 | 48  | 1.6812412 | 68  | 1.8325089 | 88  | 1.9444827 |
| 9   | 0.9542425 | 29  | 1.4623980 | 49  | 1.6901961 | 69  | 1.8388491 | 89  | 1.9493900 |
| 10  | 1.0000000 | 30  | 1.4771213 | 50  | 1.6989700 | 70  | 1.8450980 | 90  | 1.9542425 |
| 11  | 1.0413927 | 31  | 1.4913617 | 51  | 1.7075702 | 71  | 1.8512583 | 91  | 1.9590414 |
| 12  | 1.0791812 | 32  | 1.5051500 | 52  | 1.7160033 | 72  | 1.8573325 | 92  | 1.9637878 |
| 13  | 1.1139434 | 33  | 1.5185139 | 53  | 1.7242759 | 73  | 1.8633229 | 93  | 1.9684829 |
| 14  | 1.1461280 | 34  | 1.5314789 | 54  | 1.7323938 | 74  | 1.8692317 | 94  | 1.9731379 |
| 15  | 1.1760913 | 35  | 1.5440680 | 55  | 1.7403627 | 75  | 1.8750613 | 95  | 1.9777236 |
| 16  | 1.2041200 | 36  | 1.5563025 | 56  | 1.7481880 | 76  | 1.8808136 | 96  | 1.9822712 |
| 17  | 1.2304489 | 37  | 1.5682017 | 57  | 1.7558749 | 77  | 1.8864907 | 97  | 1.9867717 |
| 18  | 1.2552725 | 38  | 1.5797836 | 58  | 1.7634280 | 78  | 1.8920946 | 98  | 1.9912261 |
| 19  | 1.2787536 | 39  | 1.5910646 | 59  | 1.7708520 | 79  | 1.8976271 | 99  | 1.9956352 |
| 20  | 1.3010300 | 40  | 1.6020600 | 60  | 1.7781513 | 80  | 1.9030900 | 100 | 2.0000000 |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 100 | ·000000  | ·0004341 | ·0008677 | ·0013009 | ·0017337 | ·0021661 | ·0025980 | ·0030295 | ·0034605 | ·0038912 | 4322  |
| 101 | ·0043214 | ·0047512 | ·0051805 | ·0056094 | ·0060380 | ·0064660 | ·0068937 | ·0073210 | ·0077478 | ·0081742 | 4280  |
| 102 | ·0086002 | ·0090257 | ·0094509 | ·0098756 | ·0103000 | ·0107239 | ·0111474 | ·0115704 | ·0119931 | ·0124154 | 4237  |
| 103 | ·0128372 | ·0132587 | ·0136797 | ·0141003 | ·0145205 | ·0149403 | ·0153598 | ·0157788 | ·0161974 | ·0166155 | 4197  |
| 104 | ·0170333 | ·0174507 | ·0178677 | ·0182843 | ·0187005 | ·0191163 | ·0195317 | ·0199467 | ·0203613 | ·0207755 | 4152  |
| 105 | ·0211893 | ·0216027 | ·0220157 | ·0224284 | ·0228406 | ·0232525 | ·0236639 | ·0240750 | ·0244857 | ·0248960 | 4117  |
| 106 | ·0253039 | ·0257154 | ·0261245 | ·0265333 | ·0269416 | ·0273496 | ·0277572 | ·0281644 | ·0285713 | ·0289777 | 4078  |
| 107 | ·0293838 | ·0297895 | ·0301948 | ·0305997 | ·0310043 | ·0314085 | ·0318123 | ·0322157 | ·0326188 | ·0330214 | 4040  |
| 108 | ·0334238 | ·0338257 | ·0342273 | ·0346285 | ·0350293 | ·0354297 | ·0358298 | ·0362295 | ·0366289 | ·0370279 | 4003  |
| 109 | ·0374265 | ·0378248 | ·0382226 | ·0386202 | ·0390173 | ·0394141 | ·0398106 | ·0402066 | ·0406023 | ·0409977 | 3966  |
| 110 | ·0413927 | ·0417873 | ·0421816 | ·0425755 | ·0429691 | ·0433623 | ·0437551 | ·0441476 | ·0445398 | ·0449315 | 3931  |
| 111 | ·0453230 | ·0457141 | ·0461048 | ·0464952 | ·0468852 | ·0472749 | ·0476642 | ·0480532 | ·0484418 | ·0488301 | 3895  |
| 112 | ·0492180 | ·0496056 | ·0499929 | ·0503798 | ·0507663 | ·0511525 | ·0515384 | ·0519239 | ·0523091 | ·0526939 | 3861  |
| 113 | ·0530784 | ·0534626 | ·0538464 | ·0542299 | ·0546131 | ·0549959 | ·0553783 | ·0557605 | ·0561423 | ·0565237 | 3827  |
| 114 | ·0569049 | ·0572856 | ·0576661 | ·0580462 | ·0584260 | ·0588055 | ·0591846 | ·0595634 | ·0599419 | ·0603200 | 3796  |
| 115 | ·0606978 | ·0610753 | ·0614525 | ·0618293 | ·0622058 | ·0625820 | ·0629578 | ·0633334 | ·0637086 | ·0640834 | 3761  |
| 116 | ·0644580 | ·0648322 | ·0652061 | ·0655797 | ·0659530 | ·0663259 | ·0666986 | ·0670709 | ·0674428 | ·0678145 | 3728  |
| 117 | ·0681859 | ·0685569 | ·0689276 | ·0692980 | ·0696681 | ·0700379 | ·0704073 | ·0707765 | ·0711453 | ·0715138 | 3697  |
| 118 | ·0718820 | ·0722499 | ·0726175 | ·0729847 | ·0733517 | ·0737184 | ·0740847 | ·0744507 | ·0748164 | ·0751819 | 3665  |
| 119 | ·0755470 | ·0759118 | ·0762763 | ·0766404 | ·0770043 | ·0773679 | ·0777312 | ·0780942 | ·0784568 | ·0788192 | 3635  |
| 120 | ·0791812 | ·0795430 | ·0799045 | ·0802656 | ·0806265 | ·0809870 | ·0813473 | ·0817073 | ·0820669 | ·0824263 | 3605  |
| 121 | ·0827854 | ·0831441 | ·0835026 | ·0838608 | ·0842187 | ·0845763 | ·0849336 | ·0852906 | ·0856473 | ·0860037 | 3575  |
| 122 | ·0863598 | ·0867157 | ·0870712 | ·0874265 | ·0877814 | ·0881361 | ·0884905 | ·0888446 | ·0891984 | ·0895519 | 3546  |
| 123 | ·0899051 | ·0902581 | ·0906107 | ·0909631 | ·0913152 | ·0916670 | ·0920185 | ·0923697 | ·0927206 | ·0930713 | 3517  |
| 124 | ·0934217 | ·0937718 | ·0941216 | ·0944711 | ·0948204 | ·0951694 | ·0955180 | ·0958665 | ·0962146 | ·0965624 | 3489  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |



| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 175 | .2430380 | .2432861 | .2435341 | .2437819 | .2440296 | .2442771 | .2445245 | .2447718 | .2450189 | .2452658 | 2475  |
| 176 | .2455127 | .2457594 | .2460059 | .2462523 | .2464986 | .2467447 | .2469907 | .2472365 | .2474823 | .2477278 | 2461  |
| 177 | .2479733 | .2482186 | .2484637 | .2487087 | .2489536 | .2491984 | .2494430 | .2496874 | .2499318 | .2501759 | 2447  |
| 178 | .2504200 | .2506639 | .2509077 | .2511513 | .2513949 | .2516382 | .2518815 | .2521246 | .2523675 | .2526103 | 2433  |
| 179 | .2528530 | .2530956 | .2533380 | .2535803 | .2538224 | .2540645 | .2543063 | .2545481 | .2547897 | .2550312 | 2419  |
| 180 | .2552725 | .2555137 | .2557548 | .2559957 | .2562365 | .2564772 | .2567177 | .2569582 | .2571984 | .2574386 | 2406  |
| 181 | .2576786 | .2579185 | .2581582 | .2583978 | .2586373 | .2588766 | .2591158 | .2593549 | .2595939 | .2598327 | 2393  |
| 182 | .2600714 | .2603099 | .2605484 | .2607867 | .2610248 | .2612629 | .2615008 | .2617385 | .2619762 | .2622137 | 2379  |
| 183 | .2624511 | .2626883 | .2629255 | .2631625 | .2633993 | .2636361 | .2638727 | .2641092 | .2643455 | .2645817 | 2367  |
| 184 | .2648178 | .2650538 | .2652896 | .2655253 | .2657609 | .2659964 | .2662317 | .2664669 | .2667020 | .2669369 | 2354  |
| 185 | .2671717 | .2674064 | .2676410 | .2678754 | .2681097 | .2683439 | .2685780 | .2688119 | .2690457 | .2692794 | 2342  |
| 186 | .2695129 | .2697464 | .2699797 | .2702129 | .2704459 | .2706788 | .2709116 | .2711443 | .2713769 | .2716093 | 2329  |
| 187 | .2718416 | .2720738 | .2723058 | .2725378 | .2727696 | .2730013 | .2732328 | .2734643 | .2736956 | .2739268 | 2316  |
| 188 | .2741578 | .2743888 | .2746196 | .2748503 | .2750809 | .2753114 | .2755417 | .2757719 | .2760020 | .2762320 | 2304  |
| 189 | .2764618 | .2766915 | .2769211 | .2771506 | .2773800 | .2776092 | .2778383 | .2780673 | .2782962 | .2785250 | 2292  |
| 190 | .2787536 | .2789821 | .2792105 | .2794388 | .2796669 | .2798950 | .2801229 | .2803507 | .2805784 | .2808059 | 2280  |
| 191 | .2810334 | .2812607 | .2814879 | .2817150 | .2819419 | .2821688 | .2823955 | .2826221 | .2828486 | .2830750 | 2268  |
| 192 | .2833012 | .2835274 | .2837534 | .2839793 | .2842051 | .2844307 | .2846563 | .2848817 | .2851070 | .2853322 | 2257  |
| 193 | .2855573 | .2857823 | .2860071 | .2862319 | .2864565 | .2866810 | .2869054 | .2871296 | .2873538 | .2875778 | 2244  |
| 194 | .2878017 | .2880255 | .2882492 | .2884728 | .2886963 | .2889196 | .2891428 | .2893660 | .2895890 | .2898118 | 2233  |
| 195 | .2900346 | .2902573 | .2904798 | .2907022 | .2909246 | .2911468 | .2913689 | .2915908 | .2918127 | .2920344 | 2221  |
| 196 | .2922561 | .2924776 | .2926990 | .2929203 | .2931415 | .2933626 | .2935835 | .2938044 | .2940251 | .2942457 | 2211  |
| 197 | .2944662 | .2946866 | .2949069 | .2951271 | .2953471 | .2955671 | .2957869 | .2960067 | .2962263 | .2964458 | 2199  |
| 198 | .2966652 | .2968845 | .2971037 | .2973227 | .2975417 | .2977605 | .2979792 | .2981979 | .2984164 | .2986348 | 2188  |
| 199 | .2988531 | .2990713 | .2992893 | .2995073 | .2997252 | .2999429 | .3001605 | .3003781 | .3005955 | .3008128 | 2177  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 200 | .3010300 | .3012471 | .3014641 | .3016809 | .3018977 | .3021144 | .3023309 | .3025474 | .3027637 | .3029799 | 2167  |
| 201 | .3031961 | .3034121 | .3036280 | .3038438 | .3040595 | .3042751 | .3044905 | .3047059 | .3049212 | .3051363 | 2156  |
| 202 | .3053514 | .3055663 | .3057812 | .3059959 | .3062105 | .3064250 | .3066394 | .3068537 | .3070680 | .3072820 | 2145  |
| 203 | .3074960 | .3077099 | .3079237 | .3081374 | .3083509 | .3085644 | .3087778 | .3089910 | .3092042 | .3094172 | 2135  |
| 204 | .3096302 | .3098430 | .3100557 | .3102684 | .3104809 | .3106933 | .3109056 | .3111178 | .3113300 | .3115420 | 2124  |
| 205 | .3117539 | .3119657 | .3121774 | .3123889 | .3126004 | .3128118 | .3130231 | .3132343 | .3134454 | .3136563 | 2114  |
| 206 | .3138672 | .3140780 | .3142887 | .3144992 | .3147097 | .3149201 | .3151303 | .3153405 | .3155505 | .3157605 | 2103  |
| 207 | .3159703 | .3161801 | .3163898 | .3165993 | .3168088 | .3170181 | .3172273 | .3174365 | .3176455 | .3178545 | 2093  |
| 208 | .3180633 | .3182721 | .3184807 | .3186893 | .3188977 | .3191061 | .3193143 | .3195224 | .3197305 | .3199384 | 2083  |
| 209 | .3201463 | .3203540 | .3205617 | .3207692 | .3209767 | .3211840 | .3213913 | .3215984 | .3218055 | .3220124 | 2073  |
| 210 | .3222193 | .3224261 | .3226327 | .3228393 | .3230457 | .3232521 | .3234584 | .3236645 | .3238706 | .3240766 | 2063  |
| 211 | .3242825 | .3244882 | .3246939 | .3248995 | .3251050 | .3253104 | .3255157 | .3257209 | .3259260 | .3261310 | 2053  |
| 212 | .3263359 | .3265407 | .3267454 | .3269500 | .3271545 | .3273589 | .3275633 | .3277675 | .3279716 | .3281757 | 2044  |
| 213 | .3283796 | .3285834 | .3287872 | .3289909 | .3291944 | .3293979 | .3296012 | .3298045 | .3300077 | .3302108 | 2034  |
| 214 | .3304138 | .3306167 | .3308195 | .3310222 | .3312248 | .3314273 | .3316297 | .3318320 | .3320343 | .3322364 | 2025  |
| 215 | .3324385 | .3326404 | .3328423 | .3330440 | .3332457 | .3334473 | .3336488 | .3338501 | .3340514 | .3342526 | 2016  |
| 216 | .3344538 | .3346548 | .3348557 | .3350565 | .3352573 | .3354579 | .3356585 | .3358589 | .3360593 | .3362596 | 2006  |
| 217 | .3364597 | .3366598 | .3368598 | .3370597 | .3372595 | .3374593 | .3376589 | .3378584 | .3380579 | .3382572 | 1997  |
| 218 | .3384565 | .3386557 | .3388547 | .3390537 | .3392526 | .3394514 | .3396502 | .3398488 | .3400473 | .3402458 | 1987  |
| 219 | .3404441 | .3406424 | .3408405 | .3410386 | .3412366 | .3414345 | .3416323 | .3418301 | .3420277 | .3422252 | 1979  |
| 220 | .3424227 | .3426200 | .3428173 | .3430145 | .3432116 | .3434086 | .3436055 | .3438023 | .3439991 | .3441957 | 1970  |
| 221 | .3443923 | .3445887 | .3447851 | .3449814 | .3451776 | .3453737 | .3455698 | .3457657 | .3459615 | .3461573 | 1961  |
| 222 | .3463530 | .3465486 | .3467441 | .3469395 | .3471348 | .3473300 | .3475252 | .3477202 | .3479152 | .3481101 | 1952  |
| 223 | .3483049 | .3484996 | .3486942 | .3488887 | .3490832 | .3492775 | .3494718 | .3496660 | .3498601 | .3500541 | 1943  |
| 224 | .3502480 | .3504419 | .3506356 | .3508293 | .3510229 | .3512163 | .3514098 | .3516031 | .3517963 | .3519895 | 1934  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 225 | .3521825 | .3523755 | .3525684 | .3527612 | .3529539 | .3531465 | .3533391 | .3535316 | .3537239 | .3539162 | 1926  |
| 226 | .3541084 | .3543006 | .3544926 | .3546846 | .3548764 | .3550682 | .3552599 | .3554515 | .3556431 | .3558345 | 1918  |
| 227 | .3560259 | .3562171 | .3564083 | .3565994 | .3567905 | .3569814 | .3571723 | .3573630 | .3575537 | .3577443 | 1910  |
| 228 | .3579348 | .3581253 | .3583156 | .3585059 | .3586961 | .3588862 | .3590762 | .3592662 | .3594560 | .3596458 | 1900  |
| 229 | .3598355 | .3600251 | .3602146 | .3604041 | .3605934 | .3607827 | .3609719 | .3611610 | .3613500 | .3615390 | 1893  |
| 230 | .3617278 | .3619166 | .3621053 | .3622989 | .3624825 | .3626709 | .3628593 | .3630476 | .3632358 | .3634239 | 1884  |
| 231 | .3636120 | .3637999 | .3639878 | .3641756 | .3643634 | .3645510 | .3647386 | .3649260 | .3651134 | .3653007 | 1876  |
| 232 | .3654880 | .3656751 | .3658622 | .3660492 | .3662361 | .3664230 | .3666097 | .3667964 | .3669830 | .3671695 | 1868  |
| 233 | .3673559 | .3675423 | .3677285 | .3679147 | .3681009 | .3682869 | .3684728 | .3686587 | .3688445 | .3690302 | 1860  |
| 234 | .3692159 | .3694014 | .3695869 | .3697723 | .3699576 | .3701428 | .3703280 | .3705131 | .3706981 | .3708830 | 1852  |
| 235 | .3710679 | .3712526 | .3714373 | .3716219 | .3718065 | .3719909 | .3721753 | .3723596 | .3725438 | .3727279 | 1845  |
| 236 | .3729120 | .3730960 | .3732799 | .3734637 | .3736475 | .3738311 | .3740147 | .3741983 | .3743817 | .3745651 | 1836  |
| 237 | .3747483 | .3749316 | .3751147 | .3752977 | .3754807 | .3756636 | .3758464 | .3760292 | .3762119 | .3763944 | 1829  |
| 238 | .3765770 | .3767594 | .3769418 | .3771240 | .3773063 | .3774884 | .3776704 | .3778524 | .3780343 | .3782161 | 1821  |
| 239 | .3783979 | .3785796 | .3787612 | .3789427 | .3791241 | .3793055 | .3794868 | .3796680 | .3798492 | .3800302 | 1813  |
| 240 | .3802112 | .3803922 | .3805730 | .3807538 | .3809345 | .3811151 | .3812956 | .3814761 | .3816565 | .3818368 | 1806  |
| 241 | .3820170 | .3821972 | .3823773 | .3825573 | .3827373 | .3829171 | .3830969 | .3832767 | .3834563 | .3836359 | 1799  |
| 242 | .3838154 | .3839948 | .3841741 | .3843534 | .3845326 | .3847117 | .3848908 | .3850698 | .3852487 | .3854275 | 1791  |
| 243 | .3856063 | .3857850 | .3859636 | .3861421 | .3863206 | .3864990 | .3866773 | .3868555 | .3870337 | .3872118 | 1784  |
| 244 | .3873898 | .3875678 | .3877457 | .3879235 | .3881012 | .3882789 | .3884565 | .3886340 | .3888114 | .3889888 | 1776  |
| 245 | .3891661 | .3893433 | .3895205 | .3896975 | .3898746 | .3900515 | .3902284 | .3904052 | .3905819 | .3907585 | 1770  |
| 246 | .3909351 | .3911116 | .3912880 | .3914644 | .3916407 | .3918169 | .3919931 | .3921691 | .3923452 | .3925211 | 1762  |
| 247 | .3926970 | .3928727 | .3930485 | .3932241 | .3933997 | .3935752 | .3937506 | .3939260 | .3941013 | .3942765 | 1755  |
| 248 | .3944517 | .3946268 | .3948018 | .3949767 | .3951516 | .3953264 | .3955011 | .3956758 | .3958504 | .3960249 | 1748  |
| 249 | .3961993 | .3963737 | .3965480 | .3967223 | .3968964 | .3970705 | .3972446 | .3974185 | .3975924 | .3977663 | 1741  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 250 | .3979400 | .3981137 | .3982873 | .3984608 | .3986343 | .3988077 | .3989811 | .3991543 | .3993275 | .3995007 | 1734  |
| 251 | .3996737 | .3998467 | .4000196 | .4001925 | .4003653 | .4005380 | .4007106 | .4008832 | .4010557 | .4012282 | 1727  |
| 252 | .4014005 | .4015728 | .4017451 | .4019173 | .4020894 | .4022614 | .4024333 | .4026052 | .4027771 | .4029488 | 1720  |
| 253 | .4031205 | .4032921 | .4034637 | .4036352 | .4038066 | .4039780 | .4041492 | .4043205 | .4044916 | .4046627 | 1713  |
| 254 | .4048337 | .4050047 | .4051755 | .4053464 | .4055171 | .4056878 | .4058584 | .4060289 | .4061994 | .4063698 | 1706  |
| 255 | .4065402 | .4067105 | .4068807 | .4070508 | .4072209 | .4073909 | .4075608 | .4077307 | .4079005 | .4080703 | 1700  |
| 256 | .4082400 | .4084096 | .4085791 | .4087486 | .4089180 | .4090874 | .4092567 | .4094259 | .4095950 | .4097641 | 1693  |
| 257 | .4099331 | .4101021 | .4102710 | .4104398 | .4106085 | .4107772 | .4109459 | .4111144 | .4112829 | .4114513 | 1687  |
| 258 | .4116197 | .4117880 | .4119562 | .4121244 | .4122925 | .4124605 | .4126285 | .4127964 | .4129643 | .4131321 | 1680  |
| 259 | .4132998 | .4134674 | .4136350 | .4138025 | .4139700 | .4141374 | .4143047 | .4144719 | .4146391 | .4148063 | 1674  |
| 260 | .4149733 | .4151404 | .4153073 | .4154742 | .4156410 | .4158077 | .4159744 | .4161410 | .4163076 | .4164741 | 1667  |
| 261 | .4166405 | .4168069 | .4169732 | .4171394 | .4173056 | .4174717 | .4176377 | .4178037 | .4179696 | .4181355 | 1661  |
| 262 | .4183013 | .4184670 | .4186327 | .4187983 | .4189638 | .4191293 | .4192947 | .4194601 | .4196254 | .4197906 | 1655  |
| 263 | .4199557 | .4201208 | .4202859 | .4204509 | .4206158 | .4207806 | .4209454 | .4211101 | .4212748 | .4214394 | 1648  |
| 264 | .4216039 | .4217684 | .4219328 | .4220972 | .4222615 | .4224257 | .4225898 | .4227539 | .4229180 | .4230820 | 1642  |
| 265 | .4232459 | .4234097 | .4235735 | .4237372 | .4239009 | .4240645 | .4242281 | .4243916 | .4245550 | .4247183 | 1636  |
| 266 | .4248816 | .4250449 | .4252081 | .4253712 | .4255342 | .4256972 | .4258601 | .4260230 | .4261858 | .4263486 | 1630  |
| 267 | .4265113 | .4266739 | .4268365 | .4269990 | .4271614 | .4273238 | .4274861 | .4276484 | .4278106 | .4279727 | 1623  |
| 268 | .4281348 | .4282968 | .4284588 | .4286207 | .4287825 | .4289443 | .4291060 | .4292677 | .4294293 | .4295908 | 1618  |
| 269 | .4297523 | .4299137 | .4300751 | .4302364 | .4303976 | .4305588 | .4307199 | .4308809 | .4310419 | .4312029 | 1611  |
| 270 | .4313638 | .4315246 | .4316853 | .4318460 | .4320067 | .4321673 | .4323278 | .4324883 | .4326487 | .4328090 | 1606  |
| 271 | .4329693 | .4331295 | .4332897 | .4334498 | .4336098 | .4337698 | .4339298 | .4340896 | .4342495 | .4344092 | 1600  |
| 272 | .4345689 | .4347285 | .4348881 | .4350476 | .4352071 | .4353665 | .4355259 | .4356851 | .4358444 | .4360035 | 1594  |
| 273 | .4361626 | .4363217 | .4364807 | .4366396 | .4367985 | .4369573 | .4371161 | .4372748 | .4374334 | .4375920 | 1588  |
| 274 | .4377506 | .4379090 | .4380675 | .4382258 | .4383841 | .4385423 | .4387005 | .4388587 | .4390167 | .4391747 | 1582  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diff. |
|-----|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| 276 | 4393827  | 4394906 | 4396484 | 4398062 | 4399639 | 4401216 | 4402792 | 4404368 | 4405943 | 4407517 | 1577  |
| 276 | 4400001  | 4410664 | 4412237 | 4413809 | 4415380 | 4416951 | 4418522 | 4420092 | 4421661 | 4423230 | 1571  |
| 277 | 4424706  | 4426366 | 4427932 | 4429499 | 4431065 | 4432630 | 4434195 | 4435759 | 4437322 | 4438885 | 1565  |
| 278 | 4440444  | 4442010 | 4443571 | 4445132 | 4446692 | 4448252 | 4449811 | 4451370 | 4452928 | 4454485 | 1560  |
| 279 | 4456042  | 4457598 | 4459154 | 4460709 | 4462264 | 4463819 | 4465372 | 4466925 | 4468477 | 4470029 | 1554  |
| 280 | 4471540  | 4473131 | 4474681 | 4476231 | 4477780 | 4479329 | 4480877 | 4482424 | 4483971 | 4485517 | 1548  |
| 281 | 4487033  | 4488608 | 4490153 | 4491697 | 4493241 | 4494784 | 4496327 | 4497868 | 4499410 | 4500951 | 1543  |
| 282 | 4502411  | 4504031 | 4505570 | 4507109 | 4508647 | 4510185 | 4511722 | 4513258 | 4514794 | 4516329 | 1537  |
| 283 | 4517861  | 4519399 | 4520932 | 4522468 | 4523998 | 4525531 | 4527062 | 4528593 | 4530124 | 4531654 | 1532  |
| 284 | 4533183  | 4534712 | 4536241 | 4537769 | 4539296 | 4540823 | 4542349 | 4543875 | 4545400 | 4546924 | 1526  |
| 285 | 4548449  | 4549972 | 4551495 | 4553018 | 4554540 | 4556061 | 4557582 | 4559102 | 4560622 | 4562142 | 1522  |
| 286 | 4563650  | 4565179 | 4566696 | 4568213 | 4569730 | 4571246 | 4572762 | 4574277 | 4575791 | 4577306 | 1516  |
| 287 | 4578819  | 4580332 | 4581844 | 4583356 | 4584868 | 4586378 | 4587889 | 4589399 | 4590908 | 4592417 | 1511  |
| 288 | 4593925  | 4595433 | 4596940 | 4598446 | 4599953 | 4601454 | 4602963 | 4604468 | 4605972 | 4607475 | 1506  |
| 289 | 4608978  | 4610481 | 4611983 | 4613484 | 4614985 | 4616486 | 4617986 | 4619485 | 4620984 | 4622482 | 1501  |
| 290 | 4623980  | 4625477 | 4626974 | 4628470 | 4629966 | 4631461 | 4632956 | 4634450 | 4635944 | 4637437 | 1495  |
| 291 | 4640422  | 4641914 | 4643405 | 4644896 | 4646386 | 4647876 | 4649364 | 4650854 | 4652341 | 4653827 | 1489  |
| 292 | 4655316  | 4656802 | 4658288 | 4659774 | 4661259 | 4662743 | 4664227 | 4665711 | 4667194 | 4668677 | 1483  |
| 293 | 4669676  | 4670158 | 4671640 | 4673121 | 4674601 | 4676081 | 4677561 | 4679039 | 4680518 | 4681996 | 1478  |
| 294 | 4683473  | 4684950 | 4686427 | 4687903 | 4689378 | 4690853 | 4692327 | 4693801 | 4695275 | 4696748 | 1473  |
| 295 | 46986220 | 4699692 | 4701164 | 4702634 | 4704105 | 4705575 | 4707044 | 4708513 | 4709982 | 4711450 | 1470  |
| 296 | 4712917  | 4714384 | 4715851 | 4717317 | 4718782 | 4720247 | 4721711 | 4723175 | 4724639 | 4726102 | 1465  |
| 297 | 4727564  | 4729027 | 4730488 | 4731949 | 4733410 | 4734870 | 4736329 | 4737788 | 4739247 | 4740705 | 1460  |
| 298 | 4742163  | 4743630 | 4745076 | 4746533 | 4747988 | 4749443 | 4750898 | 4752352 | 4753808 | 4755259 | 1455  |
| 299 | 4756712  | 4758164 | 4759616 | 4761067 | 4762518 | 4763968 | 4765418 | 4766867 | 4768316 | 4769765 | 1450  |
| No. | 0        | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 300 | .4771213 | .4772660 | .4774107 | .4775553 | .4776999 | .4778445 | .4779890 | .4781334 | .4782778 | .4784222 | 1445  |
| 301 | .4785665 | .4787108 | .4788550 | .4789991 | .4791432 | .4792873 | .4794313 | .4795753 | .4797192 | .4798631 | 1440  |
| 302 | .4800069 | .4801507 | .4802945 | .4804381 | .4805818 | .4807254 | .4808689 | .4810124 | .4811559 | .4812993 | 1436  |
| 303 | .4814426 | .4815859 | .4817292 | .4818724 | .4820156 | .4821587 | .4823018 | .4824448 | .4825878 | .4827307 | 1431  |
| 304 | .4828736 | .4830164 | .4831592 | .4833020 | .4834446 | .4835873 | .4837299 | .4838725 | .4840150 | .4841574 | 1426  |
| 305 | .4842998 | .4844422 | .4845845 | .4847268 | .4848690 | .4850112 | .4851533 | .4852954 | .4854375 | .4855795 | 1422  |
| 306 | .4857214 | .4858633 | .4860052 | .4861470 | .4862888 | .4864305 | .4865722 | .4867138 | .4868554 | .4869969 | 1417  |
| 307 | .4871384 | .4872798 | .4874212 | .4875626 | .4877039 | .4878451 | .4879863 | .4881275 | .4882686 | .4884097 | 1412  |
| 308 | .4885507 | .4886917 | .4888326 | .4889735 | .4891144 | .4892552 | .4893959 | .4895366 | .4896773 | .4898179 | 1408  |
| 309 | .4899585 | .4900990 | .4902395 | .4903799 | .4905203 | .4906607 | .4908010 | .4909412 | .4910814 | .4912216 | 1403  |
| 310 | .4913617 | .4915018 | .4916418 | .4917818 | .4919217 | .4920616 | .4922015 | .4923413 | .4924810 | .4926207 | 1398  |
| 311 | .4927604 | .4929000 | .4930396 | .4931791 | .4933186 | .4934581 | .4935974 | .4937368 | .4938761 | .4940154 | 1394  |
| 312 | .4941546 | .4942938 | .4944329 | .4945720 | .4947110 | .4948500 | .4949890 | .4951279 | .4952667 | .4954056 | 1390  |
| 313 | .4955443 | .4956831 | .4958218 | .4959604 | .4960990 | .4962375 | .4963761 | .4965145 | .4966529 | .4967913 | 1386  |
| 314 | .4969296 | .4970679 | .4972062 | .4973444 | .4974825 | .4976206 | .4977587 | .4978967 | .4980347 | .4981727 | 1381  |
| 315 | .4983106 | .4984484 | .4985862 | .4987240 | .4988617 | .4989994 | .4991370 | .4992746 | .4994121 | .4995496 | 1376  |
| 316 | .4996871 | .4998245 | .4999619 | .5000992 | .5002365 | .5003737 | .5005109 | .5006481 | .5007852 | .5009222 | 1372  |
| 317 | .5010593 | .5011962 | .5013332 | .5014701 | .5016069 | .5017437 | .5018805 | .5020172 | .5021539 | .5022905 | 1367  |
| 318 | .5024271 | .5025637 | .5027002 | .5028366 | .5029731 | .5031094 | .5032458 | .5033821 | .5035183 | .5036545 | 1364  |
| 319 | .5037907 | .5039268 | .5040629 | .5041989 | .5043349 | .5044709 | .5046068 | .5047426 | .5048785 | .5050142 | 1359  |
| 320 | .5051500 | .5052857 | .5054213 | .5055569 | .5056925 | .5058280 | .5059635 | .5060990 | .5062344 | .5063697 | 1355  |
| 321 | .5065050 | .5066403 | .5067755 | .5069107 | .5070459 | .5071810 | .5073160 | .5074511 | .5075860 | .5077210 | 1351  |
| 322 | .5078559 | .5079907 | .5081255 | .5082603 | .5083950 | .5085297 | .5086644 | .5087990 | .5089335 | .5090680 | 1347  |
| 323 | .5092025 | .5093370 | .5094714 | .5096057 | .5097400 | .5098743 | .5100085 | .5101427 | .5102768 | .5104109 | 1343  |
| 324 | .5105450 | .5106790 | .5108130 | .5109469 | .5110808 | .5112147 | .5113485 | .5114823 | .5116160 | .5117497 | 1338  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 325 | .5118834 | .5120170 | .5121505 | .5122841 | .5124175 | .5125510 | .5126844 | .5128178 | .5129511 | .5130844 | 1335  |
| 326 | .5132176 | .5133508 | .5134840 | .5136171 | .5137502 | .5138832 | .5140162 | .5141491 | .5142820 | .5144149 | 1330  |
| 327 | .5145478 | .5146805 | .5148133 | .5149460 | .5150787 | .5152113 | .5153439 | .5154764 | .5156089 | .5157414 | 1326  |
| 328 | .5158738 | .5160062 | .5161386 | .5162709 | .5164031 | .5165354 | .5166676 | .5167997 | .5169318 | .5170639 | 1323  |
| 329 | .5171959 | .5173279 | .5174598 | .5175917 | .5177236 | .5178554 | .5179872 | .5181189 | .5182507 | .5183823 | 1318  |
| 330 | .5185139 | .5186455 | .5187771 | .5189086 | .5190400 | .5191715 | .5193028 | .5194342 | .5195655 | .5196968 | 1314  |
| 331 | .5198280 | .5199592 | .5200903 | .5202214 | .5203525 | .5204835 | .5206145 | .5207455 | .5208764 | .5210073 | 1310  |
| 332 | .5211381 | .5212689 | .5213996 | .5215303 | .5216610 | .5217916 | .5219222 | .5220528 | .5221833 | .5223138 | 1306  |
| 333 | .5224442 | .5225746 | .5227050 | .5228353 | .5229656 | .5230958 | .5232260 | .5233562 | .5234863 | .5236164 | 1302  |
| 334 | .5237465 | .5238765 | .5240064 | .5241364 | .5242663 | .5243961 | .5245259 | .5246557 | .5247854 | .5249151 | 1299  |
| 335 | .5250448 | .5251744 | .5253040 | .5254336 | .5255631 | .5256925 | .5258220 | .5259513 | .5260807 | .5262100 | 1295  |
| 336 | .5263393 | .5264685 | .5265977 | .5267269 | .5268560 | .5269851 | .5271141 | .5272431 | .5273721 | .5275010 | 1291  |
| 337 | .5276299 | .5277588 | .5278876 | .5280163 | .5281451 | .5282738 | .5284024 | .5285311 | .5286596 | .5287882 | 1286  |
| 338 | .5289167 | .5290452 | .5291736 | .5293020 | .5294304 | .5295587 | .5296870 | .5298152 | .5299434 | .5300716 | 1283  |
| 339 | .5301997 | .5303278 | .5304558 | .5305839 | .5307118 | .5308398 | .5309677 | .5310955 | .5312234 | .5313512 | 1279  |
| 340 | .5314789 | .5316066 | .5317343 | .5318619 | .5319896 | .5321171 | .5322446 | .5323721 | .5324996 | .5326270 | 1275  |
| 341 | .5327544 | .5328817 | .5330090 | .5331363 | .5332635 | .5333907 | .5335179 | .5336450 | .5337721 | .5338991 | 1272  |
| 342 | .5340261 | .5341531 | .5342800 | .5344069 | .5345338 | .5346606 | .5347874 | .5349141 | .5350408 | .5351675 | 1268  |
| 343 | .5352941 | .5354207 | .5355473 | .5356738 | .5358003 | .5359267 | .5360532 | .5361795 | .5363059 | .5364322 | 1264  |
| 344 | .5365584 | .5366847 | .5368109 | .5369370 | .5370631 | .5371892 | .5373153 | .5374413 | .5375673 | .5376932 | 1260  |
| 345 | .5378191 | .5379450 | .5380708 | .5381966 | .5383223 | .5384481 | .5385737 | .5386994 | .5388250 | .5389506 | 1257  |
| 346 | .5390761 | .5392016 | .5393271 | .5394525 | .5395779 | .5397032 | .5398286 | .5399538 | .5400791 | .5402043 | 1254  |
| 347 | .5403295 | .5404546 | .5405797 | .5407048 | .5408298 | .5409548 | .5410798 | .5412047 | .5413296 | .5414544 | 1250  |
| 348 | .5415792 | .5417040 | .5418288 | .5419535 | .5420781 | .5422028 | .5423274 | .5424519 | .5425765 | .5427010 | 1246  |
| 349 | .5428254 | .5429498 | .5430742 | .5431986 | .5433229 | .5434472 | .5435714 | .5436956 | .5438198 | .5439439 | 1243  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |



| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 350 | .5440680 | .5441921 | .5443161 | .5444401 | .5445641 | .5446880 | .5448119 | .5449358 | .5450596 | .5451834 | 1239  |
| 351 | .5453071 | .5454308 | .5455545 | .5456781 | .5458018 | .5459253 | .5460489 | .5461724 | .5462958 | .5464193 | 1235  |
| 352 | .5465427 | .5466660 | .5467894 | .5469126 | .5470359 | .5471591 | .5472823 | .5474055 | .5475286 | .5476517 | 1232  |
| 353 | .5477747 | .5478977 | .5480207 | .5481436 | .5482665 | .5483894 | .5485123 | .5486351 | .5487578 | .5488806 | 1229  |
| 354 | .5490033 | .5491259 | .5492486 | .5493712 | .5494937 | .5496162 | .5497387 | .5498612 | .5499836 | .5501060 | 1225  |
| 355 | .5502284 | .5503507 | .5504730 | .5505952 | .5507174 | .5508396 | .5509618 | .5510839 | .5512059 | .5513280 | 1222  |
| 356 | .5514500 | .5515720 | .5516939 | .5518158 | .5519377 | .5520595 | .5521813 | .5523031 | .5524248 | .5525465 | 1219  |
| 357 | .5526682 | .5527899 | .5529115 | .5530330 | .5531545 | .5532760 | .5533975 | .5535189 | .5536403 | .5537617 | 1214  |
| 358 | .5538830 | .5540043 | .5541256 | .5542468 | .5543680 | .5544892 | .5546103 | .5547314 | .5548524 | .5549735 | 1211  |
| 359 | .5550944 | .5552154 | .5553363 | .5554572 | .5555781 | .5556989 | .5558197 | .5559404 | .5560612 | .5561818 | 1208  |
| 360 | .5563025 | .5564231 | .5565437 | .5566643 | .5567848 | .5569053 | .5570257 | .5571461 | .5572665 | .5573869 | 1205  |
| 361 | .5575072 | .5576275 | .5577477 | .5578680 | .5579881 | .5581083 | .5582284 | .5583485 | .5584686 | .5585886 | 1202  |
| 362 | .5587086 | .5588285 | .5589484 | .5590683 | .5591882 | .5593080 | .5594278 | .5595476 | .5596673 | .5597870 | 1198  |
| 363 | .5599066 | .5600262 | .5601458 | .5602654 | .5603849 | .5605044 | .5606239 | .5607433 | .5608627 | .5609821 | 1195  |
| 364 | .5611014 | .5612207 | .5613399 | .5614592 | .5615784 | .5616975 | .5618167 | .5619358 | .5620548 | .5621739 | 1192  |
| 365 | .5622929 | .5624118 | .5625308 | .5626497 | .5627685 | .5628874 | .5630062 | .5631250 | .5632437 | .5633624 | 1188  |
| 366 | .5634811 | .5635997 | .5637183 | .5638369 | .5639555 | .5640740 | .5641925 | .5643109 | .5644293 | .5645477 | 1185  |
| 367 | .5646661 | .5647844 | .5649027 | .5650209 | .5651392 | .5652573 | .5653755 | .5654936 | .5656117 | .5657298 | 1182  |
| 368 | .5658478 | .5659658 | .5660838 | .5662017 | .5663196 | .5664375 | .5665553 | .5666731 | .5667909 | .5669087 | 1178  |
| 369 | .5670264 | .5671440 | .5672617 | .5673793 | .5674969 | .5676144 | .5677320 | .5678495 | .5679669 | .5680843 | 1176  |
| 370 | .5682017 | .5683191 | .5684364 | .5685537 | .5686710 | .5687882 | .5689054 | .5690226 | .5691397 | .5692568 | 1172  |
| 371 | .5693739 | .5694910 | .5696080 | .5697249 | .5698419 | .5699588 | .5700757 | .5701926 | .5703094 | .5704262 | 1169  |
| 372 | .5705429 | .5706597 | .5707764 | .5708930 | .5710097 | .5711263 | .5712429 | .5713594 | .5714759 | .5715924 | 1166  |
| 373 | .5717088 | .5718252 | .5719416 | .5720580 | .5721743 | .5722906 | .5724069 | .5725231 | .5726393 | .5727555 | 1163  |
| 374 | .5728716 | .5729877 | .5731038 | .5732198 | .5733358 | .5734518 | .5735678 | .5736837 | .5737996 | .5739154 | 1160  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |



| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 375 | .5740313 | .5741471 | .5742628 | .5743786 | .5744943 | .5746099 | .5747256 | .5748412 | .5749568 | .5750723 | 1157  |
| 376 | .5751878 | .5753033 | .5754188 | .5755342 | .5756496 | .5757650 | .5758803 | .5759956 | .5761109 | .5762261 | 1153  |
| 377 | .5763414 | .5764565 | .5765717 | .5766868 | .5768019 | .5769170 | .5770320 | .5771470 | .5772620 | .5773769 | 1151  |
| 378 | .5774918 | .5776067 | .5777215 | .5778363 | .5779511 | .5780659 | .5781806 | .5782953 | .5784100 | .5785246 | 1148  |
| 379 | .5786392 | .5787538 | .5788683 | .5789828 | .5790973 | .5792118 | .5793262 | .5794406 | .5795550 | .5796693 | 1145  |
| 380 | .5797836 | .5798979 | .5800121 | .5801263 | .5802405 | .5803547 | .5804688 | .5805829 | .5806969 | .5808110 | 1141  |
| 381 | .5809250 | .5810389 | .5811529 | .5812668 | .5813807 | .5814945 | .5816084 | .5817222 | .5818359 | .5819497 | 1139  |
| 382 | .5820634 | .5821770 | .5822907 | .5824043 | .5825179 | .5826314 | .5827450 | .5828585 | .5829719 | .5830854 | 1136  |
| 383 | .5831988 | .5833122 | .5834255 | .5835388 | .5836521 | .5837654 | .5838786 | .5839918 | .5841050 | .5842181 | 1133  |
| 384 | .5843312 | .5844443 | .5845574 | .5846704 | .5847834 | .5848963 | .5850093 | .5851222 | .5852351 | .5853479 | 1129  |
| 385 | .5854607 | .5855735 | .5856863 | .5857990 | .5859117 | .5860244 | .5861370 | .5862496 | .5863622 | .5864748 | 1126  |
| 386 | .5865873 | .5866998 | .5868123 | .5869247 | .5870371 | .5871495 | .5872618 | .5873742 | .5874865 | .5875987 | 1123  |
| 387 | .5877110 | .5878232 | .5879353 | .5880475 | .5881596 | .5882717 | .5883838 | .5884958 | .5886078 | .5887198 | 1120  |
| 388 | .5888317 | .5889436 | .5890555 | .5891674 | .5892792 | .5893910 | .5895028 | .5896145 | .5897263 | .5898379 | 1117  |
| 389 | .5899496 | .5900612 | .5901728 | .5902844 | .5903959 | .5905075 | .5906189 | .5907304 | .5908418 | .5909532 | 1115  |
| 390 | .5910646 | .5911760 | .5912873 | .5913986 | .5915098 | .5916210 | .5917322 | .5918434 | .5919546 | .5920657 | 1112  |
| 391 | .5921768 | .5922878 | .5923988 | .5925098 | .5926208 | .5927318 | .5928427 | .5929536 | .5930644 | .5931753 | 1109  |
| 392 | .5932861 | .5933968 | .5935076 | .5936183 | .5937290 | .5938397 | .5939503 | .5940609 | .5941715 | .5942820 | 1106  |
| 393 | .5943926 | .5945030 | .5946135 | .5947239 | .5948344 | .5949447 | .5950551 | .5951654 | .5952757 | .5953860 | 1104  |
| 394 | .5954962 | .5956064 | .5957166 | .5958268 | .5959369 | .5960470 | .5961571 | .5962671 | .5963771 | .5964871 | 1100  |
| 395 | .5965971 | .5967070 | .5968169 | .5969268 | .5970367 | .5971465 | .5972563 | .5973661 | .5974758 | .5975855 | 1098  |
| 396 | .5976952 | .5978048 | .5979145 | .5980241 | .5981336 | .5982432 | .5983527 | .5984622 | .5985717 | .5986811 | 1095  |
| 397 | .5987905 | .5988999 | .5990092 | .5991186 | .5992279 | .5993371 | .5994464 | .5995556 | .5996648 | .5997739 | 1092  |
| 398 | .5998831 | .5999922 | .6001013 | .6002103 | .6003193 | .6004283 | .6005373 | .6006462 | .6007551 | .6008640 | 1090  |
| 399 | .6009729 | .6010817 | .6011905 | .6012993 | .6014081 | .6015168 | .6016255 | .6017341 | .6018428 | .6019514 | 1087  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 400 | .6020600 | .6021686 | .6022771 | .6023856 | .6024941 | .6026025 | .6027109 | .6028193 | .6029277 | .6030361 | 1084  |
| 401 | .6031444 | .6032527 | .6033609 | .6034692 | .6035774 | .6036855 | .6037937 | .6039018 | .6040099 | .6041180 | 1082  |
| 402 | .6042261 | .6043341 | .6044421 | .6045500 | .6046580 | .6047659 | .6048738 | .6049816 | .6050895 | .6051973 | 1079  |
| 403 | .6053050 | .6054128 | .6055205 | .6056282 | .6057359 | .6058435 | .6059512 | .6060587 | .6061663 | .6062739 | 1076  |
| 404 | .6063814 | .6064889 | .6065963 | .6067037 | .6068111 | .6069185 | .6070259 | .6071332 | .6072405 | .6073478 | 1074  |
| 405 | .6074550 | .6075622 | .6076694 | .6077766 | .6078837 | .6079909 | .6080979 | .6082050 | .6083120 | .6084191 | 1071  |
| 406 | .6085260 | .6086330 | .6087399 | .6088468 | .6089537 | .6090605 | .6091674 | .6092742 | .6093809 | .6094877 | 1069  |
| 407 | .6095944 | .6097011 | .6098078 | .6099144 | .6100210 | .6101276 | .6102342 | .6103407 | .6104472 | .6105537 | 1065  |
| 408 | .6106602 | .6107666 | .6108730 | .6109794 | .6110857 | .6111921 | .6112984 | .6114046 | .6115109 | .6116171 | 1063  |
| 409 | .6117233 | .6118295 | .6119356 | .6120417 | .6121478 | .6122539 | .6123599 | .6124660 | .6125720 | .6126779 | 1060  |
| 410 | .6127839 | .6128898 | .6129957 | .6131015 | .6132074 | .6133132 | .6134189 | .6135247 | .6136304 | .6137361 | 1058  |
| 411 | .6138418 | .6139475 | .6140531 | .6141587 | .6142643 | .6143698 | .6144754 | .6145809 | .6146863 | .6147918 | 1056  |
| 412 | .6148972 | .6150026 | .6151080 | .6152133 | .6153187 | .6154240 | .6155292 | .6156345 | .6157397 | .6158449 | 1053  |
| 413 | .6159501 | .6160552 | .6161603 | .6162654 | .6163705 | .6164755 | .6165805 | .6166855 | .6167905 | .6168954 | 1050  |
| 414 | .6170003 | .6171052 | .6172101 | .6173149 | .6174197 | .6175245 | .6176293 | .6177340 | .6178387 | .6179434 | 1047  |
| 415 | .6180481 | .6181527 | .6182573 | .6183619 | .6184665 | .6185710 | .6186755 | .6187800 | .6188845 | .6189889 | 1045  |
| 416 | .6190933 | .6191977 | .6193021 | .6194064 | .6195107 | .6196150 | .6197193 | .6198235 | .6199277 | .6200319 | 1043  |
| 417 | .6201361 | .6202402 | .6203443 | .6204484 | .6205524 | .6206565 | .6207605 | .6208645 | .6209684 | .6210724 | 1040  |
| 418 | .6211763 | .6212802 | .6213840 | .6214879 | .6215917 | .6216955 | .6217992 | .6219030 | .6220067 | .6221104 | 1038  |
| 419 | .6222140 | .6223177 | .6224213 | .6225249 | .6226284 | .6227320 | .6228355 | .6229390 | .6230424 | .6231459 | 1036  |
| 420 | .6232493 | .6233527 | .6234560 | .6235594 | .6236627 | .6237660 | .6238693 | .6239725 | .6240757 | .6241789 | 1033  |
| 421 | .6242821 | .6243852 | .6244884 | .6245915 | .6246945 | .6247976 | .6249006 | .6250036 | .6251066 | .6252095 | 1030  |
| 422 | .6253125 | .6254154 | .6255182 | .6256211 | .6257239 | .6258267 | .6259295 | .6260322 | .6261350 | .6262377 | 1028  |
| 423 | .6263404 | .6264430 | .6265457 | .6266483 | .6267509 | .6268534 | .6269560 | .6270585 | .6271610 | .6272634 | 1025  |
| 424 | .6273659 | .6274683 | .6275707 | .6276730 | .6277754 | .6278777 | .6279800 | .6280823 | .6281845 | .6282867 | 1023  |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 425 | .6283889 | .6284911 | .6285933 | .6286954 | .6287975 | .6288996 | .6290016 | .6291037 | .6292057 | .6293076 | 1021  |
| 426 | .6294096 | .6295115 | .6296134 | .6297153 | .6298172 | .6299190 | .6300209 | .6301226 | .6302244 | .6303262 | 1019  |
| 427 | .6304279 | .6305296 | .6306312 | .6307329 | .6308345 | .6309361 | .6310377 | .6311393 | .6312408 | .6313423 | 1016  |
| 428 | .6314438 | .6315452 | .6316467 | .6317481 | .6318495 | .6319508 | .6320522 | .6321535 | .6322548 | .6323560 | 1014  |
| 429 | .6324573 | .6325585 | .6326597 | .6327609 | .6328620 | .6329632 | .6330643 | .6331654 | .6332664 | .6333674 | 1011  |
| 430 | .6334685 | .6335694 | .6336704 | .6337713 | .6338723 | .6339732 | .6340740 | .6341749 | .6342757 | .6343765 | 1009  |
| 431 | .6344773 | .6345780 | .6346788 | .6347795 | .6348801 | .6349808 | .6350814 | .6351820 | .6352826 | .6353832 | 1007  |
| 432 | .6354837 | .6355843 | .6356848 | .6357852 | .6358857 | .6359861 | .6360865 | .6361869 | .6362873 | .6363876 | 1004  |
| 433 | .6364879 | .6365882 | .6366884 | .6367887 | .6368889 | .6369891 | .6370893 | .6371894 | .6372895 | .6373897 | 1002  |
| 434 | .6374897 | .6375898 | .6376898 | .6377898 | .6378898 | .6379898 | .6380897 | .6381896 | .6382895 | .6383894 | 1000  |
| 435 | .6384893 | .6385891 | .6386889 | .6387887 | .6388884 | .6389882 | .6390879 | .6391876 | .6392872 | .6393869 | 997   |
| 436 | .6394865 | .6395861 | .6396857 | .6397852 | .6398847 | .6399842 | .6400837 | .6401832 | .6402826 | .6403820 | 995   |
| 437 | .6404814 | .6405808 | .6406802 | .6407795 | .6408788 | .6409781 | .6410773 | .6411765 | .6412758 | .6413749 | 993   |
| 438 | .6414741 | .6415733 | .6416724 | .6417715 | .6418705 | .6419696 | .6420686 | .6421676 | .6422666 | .6423656 | 990   |
| 439 | .6424645 | .6425634 | .6426623 | .6427612 | .6428601 | .6429589 | .6430577 | .6431565 | .6432552 | .6433540 | 988   |
| 440 | .6434527 | .6435514 | .6436500 | .6437487 | .6438473 | .6439459 | .6440445 | .6441431 | .6442416 | .6443401 | 985   |
| 441 | .6444386 | .6445371 | .6446355 | .6447339 | .6448323 | .6449307 | .6450291 | .6451274 | .6452257 | .6453240 | 984   |
| 442 | .6454223 | .6455205 | .6456187 | .6457169 | .6458151 | .6459133 | .6460114 | .6461095 | .6462076 | .6463057 | 981   |
| 443 | .6464037 | .6465018 | .6465998 | .6466977 | .6467957 | .6468936 | .6469915 | .6470894 | .6471873 | .6472851 | 979   |
| 444 | .6473830 | .6474803 | .6475786 | .6476763 | .6477741 | .6478718 | .6479695 | .6480671 | .6481648 | .6482624 | 977   |
| 445 | .6483600 | .6484576 | .6485552 | .6486527 | .6487502 | .6488477 | .6489452 | .6490426 | .6491401 | .6492375 | 975   |
| 446 | .6493349 | .6494322 | .6495296 | .6496269 | .6497242 | .6498215 | .6499187 | .6500160 | .6501132 | .6502104 | 973   |
| 447 | .6503075 | .6504047 | .6505018 | .6505989 | .6506960 | .6507930 | .6508901 | .6509871 | .6510841 | .6511811 | 971   |
| 448 | .6512780 | .6513749 | .6514719 | .6515687 | .6516656 | .6517624 | .6518593 | .6519561 | .6520528 | .6521496 | 969   |
| 449 | .6522463 | .6523431 | .6524397 | .6525364 | .6526331 | .6527297 | .6528263 | .6529229 | .6530195 | .6531160 | 966   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 450 | .6532125 | .6533090 | .6534055 | .6535019 | .6535984 | .6536948 | .6537912 | .6538876 | .6539839 | .6540802 | 965   |
| 451 | .6541765 | .6542728 | .6543691 | .6544653 | .6545616 | .6546578 | .6547539 | .6548501 | .6549462 | .6550423 | 962   |
| 452 | .6551384 | .6552345 | .6553306 | .6554266 | .6555226 | .6556186 | .6557145 | .6558105 | .6559064 | .6560023 | 960   |
| 453 | .6560982 | .6561941 | .6562899 | .6563857 | .6564815 | .6565773 | .6566730 | .6567688 | .6568645 | .6569602 | 958   |
| 454 | .6570559 | .6571515 | .6572471 | .6573427 | .6574383 | .6575339 | .6576294 | .6577250 | .6578205 | .6579159 | 955   |
| 455 | .6580114 | .6581068 | .6582023 | .6582977 | .6583930 | .6584884 | .6585837 | .6586790 | .6587743 | .6588696 | 953   |
| 456 | .6589618 | .6590601 | .6591553 | .6592505 | .6593456 | .6594408 | .6595359 | .6596310 | .6597261 | .6598212 | 951   |
| 457 | .6599162 | .6600112 | .6601062 | .6602012 | .6602962 | .6603911 | .6604860 | .6605809 | .6606758 | .6607706 | 950   |
| 458 | .6608655 | .6609603 | .6610551 | .6611499 | .6612446 | .6613393 | .6614341 | .6615287 | .6616234 | .6617181 | 947   |
| 459 | .6618127 | .6619073 | .6620019 | .6620964 | .6621910 | .6622855 | .6623800 | .6624745 | .6625690 | .6626634 | 945   |
| 460 | .6627578 | .6628522 | .6629466 | .6630410 | .6631353 | .6632296 | .6633239 | .6634182 | .6635125 | .6636067 | 944   |
| 461 | .6637009 | .6637951 | .6638893 | .6639835 | .6640776 | .6641717 | .6642658 | .6643599 | .6644539 | .6645480 | 941   |
| 462 | .6646420 | .6647360 | .6648299 | .6649239 | .6650178 | .6651117 | .6652056 | .6652995 | .6653934 | .6654872 | 939   |
| 463 | .6655810 | .6656748 | .6657686 | .6658623 | .6659560 | .6660497 | .6661434 | .6662371 | .6663307 | .6664244 | 937   |
| 464 | .6665180 | .6666116 | .6667051 | .6667987 | .6668922 | .6669857 | .6670792 | .6671727 | .6672661 | .6673595 | 935   |
| 465 | .6674530 | .6675463 | .6676397 | .6677331 | .6678264 | .6679197 | .6680130 | .6681062 | .6681995 | .6682927 | 933   |
| 466 | .6683859 | .6684791 | .6685723 | .6686654 | .6687585 | .6688516 | .6689447 | .6690378 | .6691308 | .6692239 | 931   |
| 467 | .6693169 | .6694099 | .6695028 | .6695958 | .6696887 | .6697816 | .6698745 | .6699674 | .6700602 | .6701530 | 929   |
| 468 | .6702459 | .6703386 | .6704314 | .6705242 | .6706169 | .6707096 | .6708023 | .6708950 | .6709876 | .6710802 | 927   |
| 469 | .6711728 | .6712654 | .6713580 | .6714506 | .6715431 | .6716356 | .6717281 | .6718206 | .6719130 | .6720054 | 925   |
| 470 | .6720979 | .6721903 | .6722826 | .6723750 | .6724673 | .6725596 | .6726519 | .6727442 | .6728365 | .6729287 | 923   |
| 471 | .6730209 | .6731131 | .6732053 | .6732974 | .6733896 | .6734817 | .6735738 | .6736659 | .6737579 | .6738500 | 921   |
| 472 | .6739420 | .6740340 | .6741260 | .6742179 | .6743099 | .6744018 | .6744937 | .6745856 | .6746775 | .6747693 | 919   |
| 473 | .6748611 | .6749529 | .6750447 | .6751365 | .6752283 | .6753200 | .6754117 | .6755034 | .6755951 | .6756867 | 918   |
| 474 | .6757783 | .6758700 | .6759615 | .6760531 | .6761447 | .6762362 | .6763277 | .6764192 | .6765107 | .6766022 | 915   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 475 | .6766936 | .6767850 | .6768764 | .6769678 | .6770592 | .6771505 | .6772418 | .6773332 | .6774244 | .6775157 | 913   |
| 476 | .6776070 | .6776982 | .6777894 | .6778806 | .6779718 | .6780629 | .6781540 | .6782452 | .6783362 | .6784273 | 912   |
| 477 | .6785184 | .6786094 | .6787004 | .6787914 | .6788824 | .6789734 | .6790643 | .6791552 | .6792461 | .6793370 | 910   |
| 478 | .6794279 | .6795187 | .6796096 | .6797004 | .6797912 | .6798819 | .6799727 | .6800634 | .6801541 | .6802448 | 907   |
| 479 | .6803355 | .6804262 | .6805168 | .6806074 | .6806980 | .6807886 | .6808792 | .6809697 | .6810602 | .6811507 | 905   |
| 480 | .6812412 | .6813317 | .6814222 | .6815126 | .6816030 | .6816934 | .6817838 | .6818741 | .6819645 | .6820548 | 903   |
| 481 | .6821451 | .6822354 | .6823256 | .6824159 | .6825061 | .6825963 | .6826865 | .6827766 | .6828668 | .6829569 | 902   |
| 482 | .6830470 | .6831371 | .6832272 | .6833173 | .6834073 | .6834973 | .6835873 | .6836773 | .6837673 | .6838572 | 900   |
| 483 | .6839471 | .6840370 | .6841269 | .6842168 | .6843066 | .6843965 | .6844863 | .6845761 | .6846659 | .6847556 | 898   |
| 484 | .6848454 | .6849351 | .6850248 | .6851145 | .6852041 | .6852938 | .6853834 | .6854730 | .6855626 | .6856522 | 896   |
| 485 | .6857417 | .6858313 | .6859208 | .6860103 | .6860998 | .6861892 | .6862787 | .6863681 | .6864575 | .6865469 | 894   |
| 486 | .6866363 | .6867256 | .6868150 | .6869043 | .6869936 | .6870828 | .6871721 | .6872613 | .6873506 | .6874398 | 893   |
| 487 | .6875290 | .6876181 | .6877073 | .6877964 | .6878855 | .6879746 | .6880637 | .6881528 | .6882418 | .6883308 | 891   |
| 488 | .6884198 | .6885088 | .6885978 | .6886867 | .6887757 | .6888646 | .6889535 | .6890423 | .6891312 | .6892200 | 889   |
| 489 | .6893089 | .6893977 | .6894864 | .6895752 | .6896640 | .6897527 | .6898414 | .6899301 | .6900188 | .6901074 | 887   |
| 490 | .6901961 | .6902847 | .6903733 | .6904619 | .6905505 | .6906390 | .6907275 | .6908161 | .6909046 | .6909930 | 885   |
| 491 | .6910815 | .6911699 | .6912584 | .6913468 | .6914352 | .6915235 | .6916119 | .6917002 | .6917885 | .6918768 | 884   |
| 492 | .6919651 | .6920534 | .6921416 | .6922298 | .6923180 | .6924062 | .6924944 | .6925826 | .6926707 | .6927588 | 882   |
| 493 | .6928469 | .6929350 | .6930231 | .6931111 | .6931991 | .6932872 | .6933752 | .6934631 | .6935511 | .6936390 | 880   |
| 494 | .6937269 | .6938149 | .6939027 | .6939906 | .6940785 | .6941663 | .6942541 | .6943419 | .6944297 | .6945175 | 878   |
| 495 | .6946052 | .6946929 | .6947806 | .6948683 | .6949560 | .6950437 | .6951313 | .6952189 | .6953065 | .6953941 | 876   |
| 496 | .6954817 | .6955692 | .6956568 | .6957443 | .6958318 | .6959193 | .6960067 | .6960942 | .6961816 | .6962690 | 874   |
| 497 | .6963564 | .6964438 | .6965311 | .6966185 | .6967058 | .6967931 | .6968804 | .6969676 | .6970549 | .6971421 | 873   |
| 498 | .6972293 | .6973165 | .6974037 | .6974909 | .6975780 | .6976652 | .6977523 | .6978394 | .6979264 | .6980135 | 871   |
| 499 | .6981005 | .6981876 | .6982746 | .6983616 | .6984485 | .6985355 | .6986224 | .6987093 | .6987963 | .6988831 | 870   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0       | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diff. |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| 500 | 6989700 | 6990569 | 6991437 | 6992303 | 6993178 | 6994041 | 6994908 | 6995776 | 6996643 | 6997510 | 868   |
| 501 | 6990377 | 6991244 | 7000111 | 7000977 | 7001843 | 7002701 | 7003576 | 7004441 | 7005307 | 7006172 | 868   |
| 502 | 7007037 | 7007902 | 7008767 | 7009633 | 7010496 | 7011361 | 7012225 | 7013089 | 7013953 | 7014816 | 864   |
| 503 | 7015640 | 7016543 | 7017406 | 7018269 | 7019132 | 7020005 | 7020867 | 7021720 | 7022582 | 7023444 | 863   |
| 504 | 7024205 | 7025167 | 7026029 | 7026890 | 7027751 | 7028612 | 7029472 | 7030333 | 7031193 | 7032054 | 861   |
| 505 | 7032914 | 7033774 | 7034633 | 7035493 | 7036352 | 7037212 | 7038071 | 7038930 | 7039788 | 7040647 | 859   |
| 506 | 7041505 | 7042363 | 7043221 | 7044079 | 7044937 | 7045794 | 7046653 | 7047509 | 7048366 | 7049223 | 857   |
| 507 | 7050080 | 7050936 | 7051792 | 7052649 | 7053505 | 7054361 | 7055216 | 7056072 | 7056927 | 7057782 | 856   |
| 508 | 7058637 | 7059492 | 7060347 | 7061201 | 7062055 | 7062910 | 7063764 | 7064617 | 7065471 | 7066325 | 854   |
| 509 | 7067174 | 7068031 | 7068884 | 7069737 | 7070589 | 7071442 | 7072294 | 7073146 | 7073998 | 7074850 | 853   |
| 510 | 7075702 | 7076553 | 7077405 | 7078256 | 7079107 | 7079957 | 7080808 | 7081659 | 7082509 | 7083359 | 851   |
| 511 | 7084209 | 7085059 | 7085908 | 7086758 | 7087607 | 7088456 | 7089305 | 7090154 | 7091003 | 7091851 | 849   |
| 512 | 7092700 | 7093548 | 7094396 | 7095244 | 7096091 | 7096937 | 7097786 | 7098633 | 7099480 | 7100327 | 848   |
| 513 | 7101174 | 7102020 | 7102866 | 7103713 | 7104559 | 7105404 | 7106250 | 7107096 | 7107941 | 7108786 | 846   |
| 514 | 7109631 | 7110476 | 7111321 | 7112165 | 7113010 | 7113854 | 7114698 | 7115542 | 7116385 | 7117229 | 844   |
| 515 | 7118072 | 7118915 | 7119751 | 7120591 | 7121434 | 7122277 | 7123120 | 7123971 | 7124813 | 7125655 | 843   |
| 516 | 7126497 | 7127339 | 7128180 | 7129021 | 7129862 | 7130703 | 7131544 | 7132385 | 7133225 | 7134065 | 840   |
| 517 | 7134905 | 7135745 | 7136585 | 7137425 | 7138264 | 7139104 | 7139943 | 7140782 | 7141620 | 7142459 | 839   |
| 518 | 7143298 | 7144136 | 7144974 | 7145812 | 7146650 | 7147488 | 7148325 | 7149162 | 7150000 | 7150837 | 838   |
| 519 | 7151674 | 7152510 | 7153347 | 7154183 | 7155019 | 7155856 | 7156691 | 7157527 | 7158361 | 7159198 | 836   |
| 520 | 7160033 | 7160869 | 7161703 | 7162538 | 7163373 | 7164207 | 7165042 | 7165876 | 7166710 | 7167544 | 834   |
| 521 | 7168377 | 7169211 | 7170044 | 7170877 | 7171710 | 7172543 | 7173376 | 7174208 | 7175041 | 7175873 | 833   |
| 522 | 7176705 | 7177537 | 7178369 | 7179200 | 7180032 | 7180863 | 7181694 | 7182525 | 7183356 | 7184186 | 831   |
| 523 | 7185017 | 7185847 | 7186677 | 7187507 | 7188337 | 7189167 | 7190006 | 7190826 | 7191655 | 7192484 | 830   |
| 524 | 7193313 | 7194142 | 7194970 | 7195799 | 7196627 | 7197455 | 7198283 | 7199111 | 7199938 | 7200766 | 828   |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 525 | .7201593 | .7202420 | .7203247 | .7204074 | .7204901 | .7205727 | .7206554 | .7207380 | .7208206 | .7209032 | 827   |
| 526 | .7219857 | .7210683 | .7211508 | .7212334 | .7213159 | .7213984 | .7214809 | .7215633 | .7216458 | .7217282 | 825   |
| 527 | .7218106 | .7218930 | .7219754 | .7220578 | .7221401 | .7222225 | .7223048 | .7223871 | .7224694 | .7225517 | 823   |
| 528 | .7226339 | .7227162 | .7227984 | .7228806 | .7229628 | .7230450 | .7231272 | .7232093 | .7232914 | .7233736 | 822   |
| 529 | .7234557 | .7235378 | .7236198 | .7237019 | .7237839 | .7238660 | .7239480 | .7240300 | .7241120 | .7241939 | 821   |
| 530 | .7242759 | .7243578 | .7244397 | .7245216 | .7246035 | .7246854 | .7247672 | .7248491 | .7249309 | .7250127 | 819   |
| 531 | .7250945 | .7251763 | .7252581 | .7253399 | .7254216 | .7255033 | .7255850 | .7256667 | .7257483 | .7258300 | 817   |
| 532 | .7259116 | .7259933 | .7260749 | .7261565 | .7262380 | .7263196 | .7264012 | .7264827 | .7265642 | .7266457 | 815   |
| 533 | .7267272 | .7268087 | .7268901 | .7269716 | .7270530 | .7271344 | .7272158 | .7272972 | .7273786 | .7274599 | 814   |
| 534 | .7275413 | .7276226 | .7277039 | .7277852 | .7278664 | .7279477 | .7280290 | .7281102 | .7281914 | .7282726 | 812   |
| 535 | .7283538 | .7284350 | .7285161 | .7285972 | .7286784 | .7287595 | .7288406 | .7289216 | .7290027 | .7290838 | 811   |
| 536 | .7291648 | .7292458 | .7293268 | .7294078 | .7294888 | .7295697 | .7296507 | .7297316 | .7298125 | .7298934 | 809   |
| 537 | .7299743 | .7300552 | .7301360 | .7302168 | .7302977 | .7303785 | .7304593 | .7305400 | .7306208 | .7307015 | 808   |
| 538 | .7307823 | .7308630 | .7309437 | .7310244 | .7311051 | .7311857 | .7312663 | .7313470 | .7314276 | .7315082 | 807   |
| 539 | .7315888 | .7316693 | .7317499 | .7318304 | .7319109 | .7319914 | .7320719 | .7321524 | .7322329 | .7323133 | 805   |
| 540 | .7323938 | .7324742 | .7325546 | .7326350 | .7327153 | .7327957 | .7328760 | .7329564 | .7330367 | .7331170 | 803   |
| 541 | .7331973 | .7332775 | .7333578 | .7334380 | .7335183 | .7335985 | .7336787 | .7337588 | .7338390 | .7339192 | 802   |
| 542 | .7339993 | .7340794 | .7341595 | .7342396 | .7343197 | .7343997 | .7344798 | .7345598 | .7346398 | .7347198 | 801   |
| 543 | .7347998 | .7348798 | .7349598 | .7350397 | .7351196 | .7351995 | .7352794 | .7353593 | .7354392 | .7355191 | 799   |
| 544 | .7355989 | .7356787 | .7357585 | .7358383 | .7359181 | .7359979 | .7360776 | .7361574 | .7362371 | .7363168 | 798   |
| 545 | .7363965 | .7364762 | .7365558 | .7366355 | .7367151 | .7367948 | .7368744 | .7369540 | .7370335 | .7371131 | 796   |
| 546 | .7371926 | .7372722 | .7373517 | .7374312 | .7375107 | .7375902 | .7376696 | .7377491 | .7378285 | .7379079 | 795   |
| 547 | .7379873 | .7380667 | .7381461 | .7382254 | .7383048 | .7383841 | .7384634 | .7385427 | .7386220 | .7387013 | 794   |
| 548 | .7387806 | .7388598 | .7389390 | .7390182 | .7390974 | .7391766 | .7392558 | .7393350 | .7394141 | .7394932 | 792   |
| 549 | .7395723 | .7396514 | .7397305 | .7398096 | .7398887 | .7399677 | .7400467 | .7401257 | .7402047 | .7402837 | 790   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0       | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Lat. |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|------|
| 550 | 7403627 | 7404416 | 7405206 | 7405996 | 7406784 | 7407573 | 7408362 | 7409151 | 7409939 | 7410728 | 789  |
| 551 | 7411516 | 7412304 | 7413092 | 7413880 | 7414668 | 7415456 | 7416243 | 7417030 | 7417817 | 7418604 | 790  |
| 552 | 7419391 | 7420177 | 7420964 | 7421750 | 7422537 | 7423323 | 7424109 | 7424895 | 7425680 | 7426466 | 791  |
| 553 | 7427271 | 7428057 | 7428842 | 7429627 | 7430412 | 7431196 | 7431981 | 7432765 | 7433550 | 7434334 | 792  |
| 554 | 7435128 | 7435912 | 7436695 | 7437479 | 7438262 | 7439046 | 7439829 | 7440612 | 7441395 | 7442177 | 793  |
| 555 | 7442960 | 7443742 | 7444523 | 7445304 | 7446084 | 7446864 | 7447643 | 7448422 | 7449201 | 7449979 | 794  |
| 556 | 7450761 | 7451540 | 7452319 | 7453097 | 7453875 | 7454652 | 7455429 | 7456206 | 7456982 | 7457757 | 795  |
| 557 | 7458532 | 7459309 | 7460085 | 7460861 | 7461636 | 7462411 | 7463186 | 7463960 | 7464734 | 7465508 | 796  |
| 558 | 7466282 | 7467056 | 7467829 | 7468601 | 7469373 | 7470144 | 7470915 | 7471685 | 7472455 | 7473224 | 797  |
| 559 | 7474000 | 7474771 | 7475541 | 7476311 | 7477080 | 7477849 | 7478617 | 7479385 | 7480152 | 7480919 | 798  |
| 560 | 7481680 | 7482446 | 7483211 | 7483975 | 7484738 | 7485500 | 7486262 | 7487023 | 7487784 | 7488544 | 799  |
| 561 | 7489303 | 7490061 | 7490818 | 7491574 | 7492329 | 7493084 | 7493838 | 7494591 | 7495344 | 7496096 | 800  |
| 562 | 7496847 | 7497599 | 7498350 | 7499100 | 7499849 | 7500597 | 7501344 | 7502090 | 7502835 | 7503579 | 801  |
| 563 | 7504321 | 7505064 | 7505806 | 7506547 | 7507287 | 7508026 | 7508764 | 7509501 | 7510237 | 7510972 | 802  |
| 564 | 7511707 | 7512441 | 7513174 | 7513906 | 7514637 | 7515367 | 7516096 | 7516824 | 7517551 | 7518277 | 803  |
| 565 | 7519001 | 7519725 | 7520448 | 7521170 | 7521891 | 7522611 | 7523330 | 7524048 | 7524765 | 7525481 | 804  |
| 566 | 7526196 | 7526910 | 7527623 | 7528335 | 7529046 | 7529756 | 7530465 | 7531173 | 7531880 | 7532586 | 805  |
| 567 | 7533291 | 7534000 | 7534707 | 7535413 | 7536118 | 7536822 | 7537526 | 7538229 | 7538931 | 7539633 | 806  |
| 568 | 7540334 | 7541036 | 7541737 | 7542437 | 7543136 | 7543834 | 7544531 | 7545228 | 7545924 | 7546619 | 807  |
| 569 | 7547313 | 7548009 | 7548704 | 7549398 | 7550091 | 7550783 | 7551474 | 7552164 | 7552853 | 7553541 | 808  |
| 570 | 7554228 | 7554921 | 7555613 | 7556304 | 7556994 | 7557683 | 7558371 | 7559058 | 7559744 | 7560429 | 809  |
| 571 | 7561112 | 7561796 | 7562479 | 7563161 | 7563842 | 7564522 | 7565201 | 7565879 | 7566556 | 7567232 | 810  |
| 572 | 7567907 | 7568582 | 7569256 | 7569929 | 7570601 | 7571272 | 7571942 | 7572611 | 7573279 | 7573946 | 811  |
| 573 | 7574611 | 7575282 | 7575951 | 7576619 | 7577286 | 7577952 | 7578617 | 7579281 | 7579944 | 7580606 | 812  |
| 574 | 7581267 | 7581927 | 7582586 | 7583244 | 7583901 | 7584557 | 7585212 | 7585866 | 7586519 | 7587171 | 813  |
| 575 | 7587822 | 7588473 | 7589123 | 7589772 | 7590420 | 7591067 | 7591713 | 7592358 | 7592999 | 7593640 | 814  |
| 576 | 7594280 | 7594919 | 7595557 | 7596194 | 7596829 | 7597463 | 7598096 | 7598728 | 7599359 | 7600000 | 815  |



| No. | 0       | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diff. |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| 575 | 7596678 | 7597434 | 7598189 | 7598944 | 7599699 | 7600453 | 7601208 | 7601962 | 7602717 | 7603471 | 755   |
| 576 | 7604225 | 7604979 | 7605733 | 7606486 | 7607240 | 7607993 | 7608746 | 7609500 | 7610253 | 7611005 | 753   |
| 577 | 7611758 | 7612511 | 7613263 | 7614016 | 7614768 | 7615520 | 7616272 | 7617024 | 7617775 | 7618527 | 752   |
| 578 | 7619278 | 7620030 | 7620781 | 7621533 | 7622283 | 7623034 | 7623784 | 7624535 | 7625285 | 7626035 | 751   |
| 579 | 7626786 | 7627536 | 7628286 | 7629035 | 7629785 | 7630534 | 7631284 | 7632033 | 7632782 | 7633531 | 749   |
| 580 | 7634280 | 7635029 | 7635777 | 7636526 | 7637274 | 7638023 | 7638770 | 7639518 | 7640266 | 7641014 | 748   |
| 581 | 7641761 | 7642509 | 7643256 | 7644003 | 7644750 | 7645497 | 7646244 | 7646991 | 7647737 | 7648484 | 747   |
| 582 | 7649240 | 7649976 | 7650722 | 7651468 | 7652214 | 7652959 | 7653705 | 7654450 | 7655195 | 7655941 | 746   |
| 583 | 7656686 | 7657430 | 7658175 | 7658920 | 7659664 | 7660409 | 7661153 | 7661897 | 7662641 | 7663385 | 744   |
| 584 | 7664128 | 7664872 | 7665616 | 7666359 | 7667102 | 7667845 | 7668588 | 7669331 | 7670074 | 7670816 | 743   |
| 585 | 7671559 | 7672301 | 7673043 | 7673785 | 7674527 | 7675269 | 7676011 | 7676752 | 7677494 | 7678235 | 742   |
| 586 | 7678976 | 7679717 | 7680458 | 7681199 | 7681940 | 7682680 | 7683421 | 7684161 | 7684901 | 7685641 | 740   |
| 587 | 7686381 | 7687121 | 7687860 | 7688600 | 7689339 | 7690079 | 7690818 | 7691557 | 7692296 | 7693035 | 739   |
| 588 | 7693773 | 7694512 | 7695250 | 7695988 | 7696727 | 7697465 | 7698203 | 7698940 | 7699678 | 7700416 | 738   |
| 589 | 7701153 | 7701890 | 7702627 | 7703364 | 7704101 | 7704838 | 7705575 | 7706311 | 7707048 | 7707784 | 737   |
| 590 | 7708520 | 7709256 | 7709992 | 7710728 | 7711463 | 7712199 | 7712934 | 7713670 | 7714405 | 7715140 | 735   |
| 591 | 7715875 | 7716610 | 7717344 | 7718079 | 7718813 | 7719547 | 7720282 | 7721016 | 7721750 | 7722483 | 734   |
| 592 | 7723217 | 7723951 | 7724684 | 7725417 | 7726150 | 7726884 | 7727616 | 7728349 | 7729082 | 7729815 | 733   |
| 593 | 7730547 | 7731279 | 7732011 | 7732743 | 7733475 | 7734207 | 7734939 | 7735670 | 7736402 | 7737133 | 732   |
| 594 | 7737864 | 7738596 | 7739326 | 7740057 | 7740788 | 7741519 | 7742249 | 7742979 | 7743710 | 7744440 | 731   |
| 595 | 7745170 | 7745900 | 7746629 | 7747359 | 7748088 | 7748818 | 7749547 | 7750276 | 7751005 | 7751734 | 729   |
| 596 | 7752463 | 7753191 | 7753920 | 7754648 | 7755376 | 7756104 | 7756832 | 7757560 | 7758288 | 7759016 | 728   |
| 597 | 7759743 | 7760471 | 7761198 | 7761925 | 7762652 | 7763379 | 7764106 | 7764833 | 7765559 | 7766286 | 727   |
| 598 | 7767012 | 7767738 | 7768464 | 7769190 | 7769916 | 7770642 | 7771367 | 7772093 | 7772818 | 7773543 | 726   |
| 599 | 7774268 | 7774993 | 7775718 | 7776443 | 7777167 | 7777892 | 7778616 | 7779340 | 7780065 | 7780789 | 725   |
| No. | 0       | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 600 | .7781513 | .7782236 | .7782960 | .7783683 | .7784407 | .7785130 | .7785853 | .7786576 | .7787299 | .7788022 | 723   |
| 601 | .7788745 | .7789467 | .7790190 | .7790912 | .7791634 | .7792356 | .7793078 | .7793800 | .7794522 | .7795243 | 722   |
| 602 | .7795965 | .7796686 | .7797408 | .7798129 | .7798850 | .7799571 | .7800291 | .7801012 | .7801732 | .7802453 | 721   |
| 603 | .7803173 | .7803893 | .7804613 | .7805333 | .7806053 | .7806773 | .7807492 | .7808212 | .7808931 | .7809650 | 720   |
| 604 | .7810369 | .7811088 | .7811807 | .7812526 | .7813245 | .7813963 | .7814681 | .7815400 | .7816118 | .7816836 | 718   |
| 605 | .7817554 | .7818272 | .7818989 | .7819707 | .7820424 | .7821141 | .7821859 | .7822576 | .7823293 | .7824010 | 717   |
| 606 | .7824726 | .7825443 | .7826159 | .7826876 | .7827592 | .7828308 | .7829024 | .7829740 | .7830456 | .7831171 | 716   |
| 607 | .7831887 | .7832602 | .7833318 | .7834033 | .7834748 | .7835463 | .7836178 | .7836892 | .7837607 | .7838321 | 715   |
| 608 | .7839036 | .7839750 | .7840464 | .7841178 | .7841892 | .7842606 | .7843319 | .7844033 | .7844746 | .7845460 | 713   |
| 609 | .7846173 | .7846886 | .7847599 | .7848312 | .7849024 | .7849737 | .7850450 | .7851162 | .7851874 | .7852586 | 712   |
| 610 | .7853298 | .7854010 | .7854722 | .7855434 | .7856145 | .7856857 | .7857568 | .7858279 | .7858990 | .7859701 | 711   |
| 611 | .7860412 | .7861123 | .7861833 | .7862544 | .7863254 | .7863965 | .7864675 | .7865385 | .7866095 | .7866805 | 711   |
| 612 | .7867514 | .7868224 | .7868933 | .7869643 | .7870352 | .7871061 | .7871770 | .7872479 | .7873188 | .7873896 | 710   |
| 613 | .7874605 | .7875313 | .7876021 | .7876730 | .7877438 | .7878146 | .7878854 | .7879561 | .7880269 | .7880976 | 708   |
| 614 | .7881684 | .7882391 | .7883098 | .7883805 | .7884512 | .7885219 | .7885926 | .7886632 | .7887339 | .7888045 | 707   |
| 615 | .7888751 | .7889457 | .7890163 | .7890869 | .7891575 | .7892281 | .7892986 | .7893692 | .7894397 | .7895102 | 706   |
| 616 | .7895807 | .7896512 | .7897217 | .7897922 | .7898626 | .7899331 | .7900035 | .7900739 | .7901444 | .7902148 | 705   |
| 617 | .7902852 | .7903555 | .7904259 | .7904963 | .7905666 | .7906370 | .7907073 | .7907776 | .7908479 | .7909182 | 703   |
| 618 | .7909885 | .7910587 | .7911290 | .7911992 | .7912695 | .7913397 | .7914099 | .7914801 | .7915503 | .7916205 | 702   |
| 619 | .7916906 | .7917608 | .7918309 | .7919011 | .7919712 | .7920413 | .7921114 | .7921815 | .7922516 | .7923216 | 701   |
| 620 | .7923917 | .7924617 | .7925318 | .7926018 | .7926718 | .7927418 | .7928118 | .7928817 | .7929517 | .7930217 | 700   |
| 621 | .7930916 | .7931615 | .7932314 | .7933014 | .7933712 | .7934411 | .7935110 | .7935809 | .7936507 | .7937206 | 699   |
| 622 | .7937904 | .7938602 | .7939300 | .7939998 | .7940696 | .7941394 | .7942091 | .7942789 | .7943486 | .7944183 | 698   |
| 623 | .7944880 | .7945578 | .7946274 | .7946971 | .7947668 | .7948365 | .7949061 | .7949757 | .7950454 | .7951150 | 697   |
| 624 | .7951846 | .7952542 | .7953238 | .7953933 | .7954629 | .7955324 | .7956020 | .7956715 | .7957410 | .7958105 | 696   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 625 | .7958800 | .7959495 | .7960190 | .7960884 | .7961579 | .7962273 | .7962967 | .7963662 | .7964356 | .7965050 | 694   |
| 626 | .7965743 | .7966437 | .7967131 | .7967824 | .7968517 | .7969211 | .7969904 | .7970597 | .7971290 | .7971983 | 693   |
| 627 | .7972675 | .7973368 | .7974060 | .7974753 | .7975445 | .7976137 | .7976829 | .7977521 | .7978213 | .7978905 | 692   |
| 628 | .7979596 | .7980288 | .7980979 | .7981671 | .7982362 | .7983053 | .7983744 | .7984435 | .7985125 | .7985816 | 691   |
| 629 | .7986506 | .7987197 | .7987887 | .7988577 | .7989267 | .7989957 | .7990647 | .7991337 | .7992027 | .7992716 | 690   |
| 630 | .7993405 | .7994095 | .7994784 | .7995473 | .7996162 | .7996851 | .7997540 | .7998228 | .7998917 | .7999605 | 689   |
| 631 | .8000294 | .8000982 | .8001670 | .8002358 | .8003046 | .8003734 | .8004421 | .8005109 | .8005796 | .8006484 | 688   |
| 632 | .8007171 | .8007858 | .8008545 | .8009232 | .8009919 | .8010605 | .8011292 | .8011978 | .8012665 | .8013351 | 687   |
| 633 | .8014037 | .8014723 | .8015409 | .8016095 | .8016781 | .8017466 | .8018152 | .8018837 | .8019522 | .8020208 | 686   |
| 634 | .8020893 | .8021578 | .8022262 | .8022947 | .8023632 | .8024316 | .8025001 | .8025685 | .8026369 | .8027053 | 685   |
| 635 | .8027737 | .8028421 | .8029105 | .8029789 | .8030472 | .8031156 | .8031839 | .8032522 | .8033205 | .8033888 | 684   |
| 636 | .8034571 | .8035254 | .8035937 | .8036619 | .8037302 | .8037984 | .8038666 | .8039348 | .8040031 | .8040712 | 682   |
| 637 | .8041394 | .8042076 | .8042758 | .8043439 | .8044121 | .8044802 | .8045483 | .8046164 | .8046845 | .8047526 | 681   |
| 638 | .8048207 | .8048887 | .8049568 | .8050248 | .8050929 | .8051609 | .8052289 | .8052969 | .8053649 | .8054329 | 680   |
| 639 | .8055009 | .8055688 | .8056368 | .8057047 | .8057726 | .8058405 | .8059085 | .8059764 | .8060442 | .8061121 | 679   |
| 640 | .8061800 | .8062478 | .8063157 | .8063835 | .8064513 | .8065191 | .8065869 | .8066547 | .8067225 | .8067903 | 678   |
| 641 | .8068580 | .8069258 | .8069935 | .8070612 | .8071290 | .8071967 | .8072644 | .8073320 | .8073997 | .8074674 | 677   |
| 642 | .8075350 | .8076027 | .8076703 | .8077379 | .8078055 | .8078731 | .8079407 | .8080083 | .8080759 | .8081434 | 676   |
| 643 | .8082110 | .8082785 | .8083460 | .8084136 | .8084811 | .8085486 | .8086160 | .8086835 | .8087510 | .8088184 | 675   |
| 644 | .8088859 | .8089533 | .8090207 | .8090881 | .8091555 | .8092229 | .8092903 | .8093577 | .8094250 | .8094924 | 674   |
| 645 | .8095597 | .8096270 | .8096944 | .8097617 | .8098290 | .8098962 | .8099635 | .8100308 | .8100980 | .8101653 | 673   |
| 646 | .8102325 | .8102997 | .8103670 | .8104342 | .8105013 | .8105685 | .8106357 | .8107029 | .8107700 | .8108372 | 672   |
| 647 | .8109043 | .8109714 | .8110385 | .8111056 | .8111727 | .8112398 | .8113068 | .8113739 | .8114409 | .8115080 | 671   |
| 648 | .8115750 | .8116420 | .8117090 | .8117760 | .8118430 | .8119100 | .8119769 | .8120439 | .8121108 | .8121778 | 670   |
| 649 | .8122447 | .8123116 | .8123785 | .8124454 | .8125123 | .8125792 | .8126460 | .8127129 | .8127797 | .8128465 | 669   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 650 | .8129134 | .8129802 | .8130470 | .8131138 | .8131805 | .8132473 | .8133141 | .8133808 | .8134475 | .8135143 | 668   |
| 651 | .8135810 | .8136477 | .8137144 | .8137811 | .8138478 | .8139144 | .8139811 | .8140477 | .8141144 | .8141810 | 667   |
| 652 | .8142476 | .8143142 | .8143808 | .8144474 | .8145140 | .8145805 | .8146471 | .8147136 | .8147801 | .8148467 | 666   |
| 653 | .8149132 | .8149797 | .8150462 | .8151127 | .8151791 | .8152456 | .8153120 | .8153785 | .8154449 | .8155113 | 665   |
| 654 | .8155777 | .8156441 | .8157105 | .8157769 | .8158433 | .8159097 | .8159760 | .8160423 | .8161087 | .8161750 | 664   |
| 655 | .8162413 | .8163076 | .8163739 | .8164402 | .8165064 | .8165727 | .8166389 | .8167052 | .8167714 | .8168376 | 663   |
| 656 | .8169038 | .8169700 | .8170362 | .8171024 | .8171686 | .8172347 | .8173009 | .8173670 | .8174331 | .8174993 | 662   |
| 657 | .8175654 | .8176315 | .8176976 | .8177636 | .8178297 | .8178958 | .8179618 | .8180278 | .8180939 | .8181599 | 661   |
| 658 | .8182259 | .8182919 | .8183579 | .8184239 | .8184898 | .8185558 | .8186217 | .8186877 | .8187536 | .8188195 | 660   |
| 659 | .8188854 | .8189513 | .8190172 | .8190831 | .8191489 | .8192148 | .8192806 | .8193465 | .8194123 | .8194781 | 658   |
| 660 | .8195439 | .8196097 | .8196755 | .8197413 | .8198071 | .8198728 | .8199386 | .8200043 | .8200700 | .8201358 | 657   |
| 661 | .8202015 | .8202672 | .8203328 | .8203985 | .8204642 | .8205298 | .8205955 | .8206611 | .8207268 | .8207924 | 656   |
| 662 | .8208580 | .8209236 | .8209892 | .8210548 | .8211203 | .8211859 | .8212514 | .8213170 | .8213825 | .8214480 | 655   |
| 663 | .8215135 | .8215790 | .8216445 | .8217100 | .8217755 | .8218409 | .8219064 | .8219718 | .8220372 | .8221027 | 654   |
| 664 | .8221681 | .8222335 | .8222989 | .8223643 | .8224296 | .8224950 | .8225603 | .8226257 | .8226910 | .8227563 | 653   |
| 665 | .8228216 | .8228869 | .8229522 | .8230175 | .8230828 | .8231481 | .8232133 | .8232786 | .8233438 | .8234090 | 652   |
| 666 | .8234742 | .8235394 | .8236046 | .8236698 | .8237350 | .8238002 | .8238653 | .8239305 | .8239956 | .8240607 | 651   |
| 667 | .8241258 | .8241909 | .8242560 | .8243211 | .8243862 | .8244513 | .8245163 | .8245814 | .8246464 | .8247114 | 651   |
| 668 | .8247765 | .8248415 | .8249065 | .8249715 | .8250364 | .8251014 | .8251664 | .8252313 | .8252963 | .8253612 | 650   |
| 669 | .8254261 | .8254910 | .8255559 | .8256208 | .8256857 | .8257506 | .8258154 | .8258803 | .8259451 | .8260100 | 649   |
| 670 | .8260748 | .8261396 | .8262044 | .8262692 | .8263340 | .8263988 | .8264635 | .8265283 | .8265931 | .8266578 | 648   |
| 671 | .8267225 | .8267872 | .8268519 | .8269166 | .8269813 | .8270460 | .8271107 | .8271753 | .8272400 | .8273046 | 647   |
| 672 | .8273693 | .8274339 | .8274985 | .8275631 | .8276277 | .8276923 | .8277569 | .8278214 | .8278860 | .8279505 | 646   |
| 673 | .8280151 | .8280796 | .8281441 | .8282086 | .8282731 | .8283376 | .8284021 | .8284665 | .8285310 | .8285955 | 645   |
| 674 | .8286599 | .8287243 | .8287887 | .8288532 | .8289176 | .8289820 | .8290463 | .8291107 | .8291751 | .8292394 | 644   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 675 | .8293038 | .8293681 | .8294324 | .8294967 | .8295611 | .8296254 | .8296896 | .8297539 | .8298182 | .8298824 | 643   |
| 676 | .8299467 | .8300109 | .8300752 | .8301394 | .8302036 | .8302678 | .8303320 | .8303962 | .8304604 | .8305245 | 642   |
| 677 | .8305887 | .8306528 | .8307169 | .8307811 | .8308452 | .8309093 | .8309734 | .8310375 | .8311016 | .8311656 | 641   |
| 678 | .8312297 | .8312937 | .8313578 | .8314218 | .8314858 | .8315499 | .8316139 | .8316778 | .8317418 | .8318058 | 640   |
| 679 | .8318698 | .8319337 | .8319977 | .8320616 | .8321255 | .8321895 | .8322534 | .8323173 | .8323812 | .8324450 | 639   |
| 680 | .8325089 | .8325728 | .8326366 | .8327005 | .8327643 | .8328281 | .8328919 | .8329558 | .8330195 | .8330833 | 638   |
| 681 | .8331471 | .8332109 | .8332746 | .8333384 | .8334021 | .8334659 | .8335296 | .8335933 | .8336570 | .8337207 | 637   |
| 682 | .8337844 | .8338480 | .8339117 | .8339754 | .8340390 | .8341027 | .8341663 | .8342299 | .8342935 | .8343571 | 636   |
| 683 | .8344207 | .8344843 | .8345479 | .8346114 | .8346750 | .8347385 | .8348021 | .8348656 | .8349291 | .8349926 | 635   |
| 684 | .8350561 | .8351196 | .8351831 | .8352465 | .8353100 | .8353735 | .8354369 | .8355003 | .8355638 | .8356272 | 634   |
| 685 | .8356906 | .8357540 | .8358174 | .8358807 | .8359441 | .8360075 | .8360708 | .8361341 | .8361975 | .8362608 | 633   |
| 686 | .8363241 | .8363874 | .8364507 | .8365140 | .8365773 | .8366405 | .8367038 | .8367670 | .8368303 | .8368935 | 632   |
| 687 | .8369567 | .8370199 | .8370832 | .8371463 | .8372095 | .8372727 | .8373359 | .8373990 | .8374622 | .8375253 | 632   |
| 688 | .8375884 | .8376516 | .8377147 | .8377778 | .8378409 | .8379039 | .8379670 | .8380301 | .8380931 | .8381562 | 631   |
| 689 | .8382192 | .8382822 | .8383453 | .8384083 | .8384713 | .8385343 | .8385973 | .8386602 | .8387232 | .8387861 | 630   |
| 690 | .8388491 | .8389120 | .8389750 | .8390379 | .8391008 | .8391637 | .8392266 | .8392895 | .8393523 | .8394152 | 629   |
| 691 | .8394780 | .8395409 | .8396037 | .8396666 | .8397294 | .8397922 | .8398550 | .8399178 | .8399806 | .8400433 | 628   |
| 692 | .8401061 | .8401688 | .8402316 | .8402943 | .8403571 | .8404198 | .8404825 | .8405452 | .8406079 | .8406706 | 627   |
| 693 | .8407332 | .8407959 | .8408586 | .8409212 | .8409838 | .8410465 | .8411091 | .8411717 | .8412343 | .8412969 | 626   |
| 694 | .8413595 | .8414220 | .8414846 | .8415472 | .8416097 | .8416723 | .8417348 | .8417973 | .8418598 | .8419223 | 625   |
| 695 | .8419848 | .8420473 | .8421098 | .8421722 | .8422347 | .8422971 | .8423596 | .8424220 | .8424844 | .8425468 | 624   |
| 696 | .8426092 | .8426716 | .8427340 | .8427964 | .8428588 | .8429211 | .8429835 | .8430458 | .8431081 | .8431705 | 624   |
| 697 | .8432328 | .8432951 | .8433574 | .8434197 | .8434819 | .8435442 | .8436065 | .8436687 | .8437310 | .8437932 | 623   |
| 698 | .8438554 | .8439176 | .8439798 | .8440420 | .8441042 | .8441664 | .8442286 | .8442907 | .8443529 | .8444150 | 622   |
| 699 | .8444772 | .8445393 | .8446014 | .8446635 | .8447256 | .8447877 | .8448498 | .8449119 | .8449739 | .8450360 | 621   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 700 | .8450980 | .8451601 | .8452221 | .8452841 | .8453461 | .8454081 | .8454701 | .8455321 | .8455941 | .8456561 | 620   |
| 701 | .8457180 | .8457800 | .8458419 | .8459038 | .8459658 | .8460277 | .8460896 | .8461515 | .8462134 | .8462752 | 619   |
| 702 | .8463371 | .8463990 | .8464608 | .8465227 | .8465845 | .8466463 | .8467081 | .8467700 | .8468318 | .8468935 | 618   |
| 703 | .8469553 | .8470171 | .8470789 | .8471406 | .8472024 | .8472641 | .8473258 | .8473876 | .8474493 | .8475110 | 617   |
| 704 | .8475727 | .8476343 | .8476960 | .8477577 | .8478193 | .8478810 | .8479426 | .8480043 | .8480659 | .8481275 | 616   |
| 705 | .8481891 | .8482507 | .8483123 | .8483739 | .8484355 | .8484970 | .8485586 | .8486201 | .8486817 | .8487432 | 615   |
| 706 | .8488017 | .8488662 | .8489277 | .8489892 | .8490507 | .8491122 | .8491736 | .8492351 | .8492965 | .8493580 | 615   |
| 707 | .8494194 | .8494808 | .8495423 | .8496037 | .8496651 | .8497264 | .8497878 | .8498492 | .8499106 | .8499719 | 614   |
| 708 | .8500333 | .8500946 | .8501559 | .8502172 | .8502786 | .8503399 | .8504011 | .8504624 | .8505237 | .8505850 | 613   |
| 709 | .8506462 | .8507075 | .8507687 | .8508300 | .8508912 | .8509524 | .8510136 | .8510748 | .8511360 | .8511972 | 612   |
| 710 | .8512583 | .8513195 | .8513807 | .8514418 | .8515030 | .8515641 | .8516252 | .8516863 | .8517474 | .8518085 | 611   |
| 711 | .8518696 | .8519307 | .8519917 | .8520528 | .8521139 | .8521749 | .8522359 | .8522970 | .8523580 | .8524190 | 610   |
| 712 | .8524800 | .8525410 | .8526020 | .8526629 | .8527239 | .8527849 | .8528458 | .8529068 | .8529677 | .8530286 | 609   |
| 713 | .8530895 | .8531504 | .8532113 | .8532722 | .8533331 | .8533940 | .8534548 | .8535157 | .8535765 | .8536374 | 608   |
| 714 | .8536982 | .8537590 | .8538198 | .8538807 | .8539414 | .8540022 | .8540630 | .8541238 | .8541845 | .8542453 | 607   |
| 715 | .8543060 | .8543668 | .8544275 | .8544882 | .8545489 | .8546096 | .8546703 | .8547310 | .8547917 | .8548524 | 607   |
| 716 | .8549130 | .8549737 | .8550343 | .8550950 | .8551556 | .8552162 | .8552768 | .8553374 | .8553980 | .8554586 | 606   |
| 717 | .8555192 | .8555797 | .8556403 | .8557008 | .8557614 | .8558219 | .8558824 | .8559429 | .8560035 | .8560640 | 605   |
| 718 | .8561244 | .8561849 | .8562454 | .8563059 | .8563663 | .8564268 | .8564872 | .8565476 | .8566081 | .8566685 | 604   |
| 719 | .8567289 | .8567893 | .8568497 | .8569101 | .8569704 | .8570308 | .8570912 | .8571515 | .8572118 | .8572722 | 603   |
| 720 | .8573325 | .8573928 | .8574531 | .8575134 | .8575737 | .8576340 | .8576943 | .8577545 | .8578148 | .8578750 | 603   |
| 721 | .8579353 | .8579955 | .8580557 | .8581159 | .8581761 | .8582363 | .8582965 | .8583567 | .8584169 | .8584770 | 602   |
| 722 | .8585372 | .8585973 | .8586575 | .8587176 | .8587777 | .8588379 | .8588980 | .8589581 | .8590181 | .8590782 | 601   |
| 723 | .8591383 | .8591984 | .8592584 | .8593185 | .8593785 | .8594385 | .8594986 | .8595586 | .8596186 | .8596786 | 600   |
| 724 | .8597386 | .8597985 | .8598585 | .8599185 | .8599784 | .8600384 | .8600983 | .8601583 | .8602182 | .8602781 | 600   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 725 | .8603380 | .8603979 | .8604578 | .8605177 | .8605776 | .8606374 | .8606973 | .8607571 | .8608170 | .8608768 | 599   |
| 726 | .8609366 | .8609964 | .8610562 | .8611160 | .8611758 | .8612356 | .8612954 | .8613552 | .8614149 | .8614747 | 598   |
| 727 | .8615344 | .8615941 | .8616539 | .8617136 | .8617733 | .8618330 | .8618927 | .8619524 | .8620121 | .8620717 | 597   |
| 728 | .8621314 | .8621910 | .8622507 | .8623103 | .8623699 | .8624296 | .8624892 | .8625488 | .8626084 | .8626680 | 596   |
| 729 | .8627275 | .8627871 | .8628467 | .8629062 | .8629658 | .8630253 | .8630848 | .8631443 | .8632039 | .8632634 | 595   |
| 730 | .8633229 | .8633823 | .8634418 | .8635013 | .8635608 | .8636202 | .8636797 | .8637391 | .8637985 | .8638580 | 594   |
| 731 | .8639174 | .8639768 | .8640362 | .8640956 | .8641550 | .8642143 | .8642737 | .8643331 | .8643924 | .8644517 | 593   |
| 732 | .8645111 | .8645704 | .8646297 | .8646890 | .8647483 | .8648076 | .8648669 | .8649262 | .8649855 | .8650447 | 592   |
| 733 | .8651040 | .8651632 | .8652225 | .8652817 | .8653409 | .8654001 | .8654593 | .8655185 | .8655777 | .8656369 | 592   |
| 734 | .8656961 | .8657552 | .8658144 | .8658735 | .8659327 | .8659918 | .8660509 | .8661100 | .8661691 | .8662282 | 591   |
| 735 | .8662873 | .8663464 | .8664055 | .8664646 | .8665236 | .8665827 | .8666417 | .8667008 | .8667598 | .8668188 | 591   |
| 736 | .8668778 | .8669368 | .8669958 | .8670548 | .8671138 | .8671728 | .8672317 | .8672907 | .8673496 | .8674086 | 590   |
| 737 | .8674675 | .8675264 | .8675853 | .8676442 | .8677031 | .8677620 | .8678209 | .8678798 | .8679387 | .8679975 | 589   |
| 738 | .8680564 | .8681152 | .8681740 | .8682329 | .8682917 | .8683505 | .8684093 | .8684681 | .8685269 | .8685857 | 588   |
| 739 | .8686444 | .8687032 | .8687620 | .8688207 | .8688794 | .8689382 | .8689969 | .8690556 | .8691143 | .8691730 | 588   |
| 740 | .8692317 | .8692904 | .8693491 | .8694077 | .8694664 | .8695251 | .8695837 | .8696423 | .8697010 | .8697596 | 587   |
| 741 | .8698182 | .8698768 | .8699354 | .8699940 | .8700526 | .8701112 | .8701697 | .8702283 | .8702868 | .8703454 | 586   |
| 742 | .8704039 | .8704624 | .8705210 | .8705795 | .8706380 | .8706965 | .8707549 | .8708134 | .8708719 | .8709304 | 585   |
| 743 | .8709888 | .8710473 | .8711057 | .8711641 | .8712226 | .8712810 | .8713394 | .8713978 | .8714562 | .8715146 | 584   |
| 744 | .8715729 | .8716313 | .8716897 | .8717480 | .8718064 | .8718647 | .8719230 | .8719814 | .8720397 | .8720980 | 583   |
| 745 | .8721563 | .8722146 | .8722728 | .8723311 | .8723894 | .8724476 | .8725059 | .8725641 | .8726224 | .8726806 | 582   |
| 746 | .8727388 | .8727970 | .8728552 | .8729134 | .8729716 | .8730298 | .8730880 | .8731462 | .8732043 | .8732625 | 582   |
| 747 | .8733206 | .8733787 | .8734369 | .8734950 | .8735531 | .8736112 | .8736693 | .8737274 | .8737855 | .8738435 | 581   |
| 748 | .8739016 | .8739597 | .8740177 | .8740757 | .8741338 | .8741918 | .8742498 | .8743078 | .8743658 | .8744238 | 580   |
| 749 | .8744818 | .8745398 | .8745978 | .8746557 | .8747137 | .8747716 | .8748296 | .8748875 | .8749454 | .8750034 | 579   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |



| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 750 | .8750613 | .8751192 | .8751771 | .8752349 | .8752928 | .8753507 | .8754086 | .8754664 | .8755243 | .8755821 | 579   |
| 751 | .8756399 | .8756978 | .8757556 | .8758134 | .8758712 | .8759290 | .8759868 | .8760446 | .8761023 | .8761601 | 578   |
| 752 | .8762178 | .8762756 | .8763333 | .8763911 | .8764489 | .8765065 | .8765642 | .8766219 | .8766796 | .8767373 | 577   |
| 753 | .8767950 | .8768526 | .8769103 | .8769680 | .8770256 | .8770833 | .8771409 | .8771985 | .8772561 | .8773137 | 577   |
| 754 | .8773713 | .8774289 | .8774865 | .8775441 | .8776017 | .8776592 | .8777168 | .8777743 | .8778319 | .8778894 | 576   |
| 755 | .8779470 | .8780045 | .8780620 | .8781195 | .8781770 | .8782345 | .8782919 | .8783494 | .8784069 | .8784643 | 575   |
| 756 | .8785218 | .8785792 | .8786367 | .8786941 | .8787515 | .8788089 | .8788663 | .8789237 | .8789811 | .8790385 | 574   |
| 757 | .8790959 | .8791532 | .8792106 | .8792680 | .8793253 | .8793826 | .8794400 | .8794973 | .8795546 | .8796119 | 574   |
| 758 | .8796692 | .8797265 | .8797838 | .8798411 | .8798983 | .8799556 | .8800128 | .8800701 | .8801273 | .8801846 | 573   |
| 759 | .8802418 | .8802990 | .8803562 | .8804134 | .8804706 | .8805278 | .8805850 | .8806421 | .8806993 | .8807564 | 572   |
| 760 | .8808136 | .8808707 | .8809279 | .8809850 | .8810421 | .8810992 | .8811563 | .8812134 | .8812705 | .8813276 | 571   |
| 761 | .8813847 | .8814417 | .8814988 | .8815558 | .8816129 | .8816699 | .8817269 | .8817840 | .8818410 | .8818980 | 570   |
| 762 | .8819550 | .8820120 | .8820689 | .8821259 | .8821829 | .8822398 | .8822968 | .8823537 | .8824107 | .8824676 | 569   |
| 763 | .8825245 | .8825815 | .8826384 | .8826953 | .8827522 | .8828090 | .8828659 | .8829228 | .8829797 | .8830365 | 569   |
| 764 | .8830934 | .8831502 | .8832070 | .8832639 | .8833207 | .8833775 | .8834343 | .8834911 | .8835479 | .8836047 | 568   |
| 765 | .8836614 | .8837182 | .8837750 | .8838317 | .8838885 | .8839452 | .8840019 | .8840586 | .8841154 | .8841721 | 567   |
| 766 | .8842288 | .8842855 | .8843421 | .8843988 | .8844555 | .8845122 | .8845688 | .8846255 | .8846821 | .8847387 | 567   |
| 767 | .8847954 | .8848520 | .8849086 | .8849652 | .8850218 | .8850784 | .8851350 | .8851915 | .8852481 | .8853047 | 566   |
| 768 | .8853612 | .8854178 | .8854743 | .8855308 | .8855874 | .8856439 | .8857004 | .8857569 | .8858134 | .8858699 | 565   |
| 769 | .8859263 | .8859828 | .8860393 | .8860957 | .8861522 | .8862086 | .8862651 | .8863215 | .8863779 | .8864343 | 564   |
| 770 | .8864907 | .8865471 | .8866035 | .8866599 | .8867163 | .8867726 | .8868290 | .8868854 | .8869417 | .8869980 | 564   |
| 771 | .8870544 | .8871107 | .8871670 | .8872233 | .8872796 | .8873359 | .8873922 | .8874485 | .8875048 | .8875610 | 563   |
| 772 | .8876173 | .8876736 | .8877298 | .8877860 | .8878423 | .8878985 | .8879547 | .8880109 | .8880671 | .8881233 | 562   |
| 773 | .8881795 | .8882357 | .8882918 | .8883480 | .8884042 | .8884603 | .8885165 | .8885726 | .8886287 | .8886848 | 562   |
| 774 | .8887410 | .8887971 | .8888532 | .8889093 | .8889653 | .8890214 | .8890775 | .8891336 | .8891896 | .8892457 | 561   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |



| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 775 | .8893017 | .8893577 | .8894138 | .8894698 | .8895258 | .8895818 | .8896378 | .8896938 | .8897498 | .8898058 | 560   |
| 776 | .8898617 | .8899177 | .8899736 | .8900296 | .8900855 | .8901415 | .8901974 | .8902533 | .8903092 | .8903651 | 559   |
| 777 | .8904210 | .8904769 | .8905328 | .8905887 | .8906445 | .8907004 | .8907563 | .8908121 | .8908679 | .8909238 | 558   |
| 778 | .8909796 | .8910354 | .8910912 | .8911470 | .8912028 | .8912586 | .8913144 | .8913702 | .8914259 | .8914817 | 558   |
| 779 | .8915375 | .8915932 | .8916489 | .8917047 | .8917604 | .8918161 | .8918718 | .8919275 | .8919832 | .8920389 | 557   |
| 780 | .8920946 | .8921503 | .8922059 | .8922616 | .8923173 | .8923729 | .8924285 | .8924842 | .8925398 | .8925954 | 557   |
| 781 | .8926510 | .8927066 | .8927622 | .8928178 | .8928734 | .8929290 | .8929846 | .8930401 | .8930957 | .8931512 | 556   |
| 782 | .8932068 | .8932623 | .8933178 | .8933733 | .8934288 | .8934843 | .8935398 | .8935953 | .8936508 | .8937063 | 555   |
| 783 | .8937618 | .8938172 | .8938727 | .8939281 | .8939836 | .8940390 | .8940944 | .8941498 | .8942053 | .8942607 | 555   |
| 784 | .8943161 | .8943715 | .8944268 | .8944822 | .8945376 | .8945929 | .8946483 | .8947037 | .8947590 | .8948143 | 554   |
| 785 | .8948697 | .8949250 | .8949803 | .8950356 | .8950909 | .8951462 | .8952015 | .8952568 | .8953120 | .8953673 | 553   |
| 786 | .8954225 | .8954778 | .8955330 | .8955883 | .8956435 | .8956987 | .8957539 | .8958092 | .8958644 | .8959195 | 552   |
| 787 | .8959747 | .8960299 | .8960851 | .8961403 | .8961954 | .8962506 | .8963057 | .8963608 | .8964160 | .8964711 | 551   |
| 788 | .8965262 | .8965813 | .8966364 | .8966915 | .8967466 | .8968017 | .8968568 | .8969118 | .8969669 | .8970220 | 551   |
| 789 | .8970770 | .8971320 | .8971871 | .8972421 | .8972971 | .8973521 | .8974071 | .8974621 | .8975171 | .8975721 | 550   |
| 790 | .8976271 | .8976821 | .8977370 | .8977920 | .8978469 | .8979019 | .8979568 | .8980117 | .8980667 | .8981216 | 549   |
| 791 | .8981765 | .8982314 | .8982863 | .8983412 | .8983960 | .8984509 | .8985058 | .8985606 | .8986155 | .8986703 | 549   |
| 792 | .8987252 | .8987800 | .8988348 | .8988897 | .8989445 | .8989993 | .8990541 | .8991089 | .8991636 | .8992184 | 548   |
| 793 | .8992732 | .8993279 | .8993827 | .8994375 | .8994922 | .8995469 | .8996017 | .8996564 | .8997111 | .8997658 | 547   |
| 794 | .8998205 | .8998752 | .8999299 | .8999846 | .9000392 | .9000939 | .9001486 | .9002032 | .9002579 | .9003125 | 547   |
| 795 | .9003671 | .9004218 | .9004764 | .9005310 | .9005856 | .9006402 | .9006948 | .9007494 | .9008039 | .9008585 | 546   |
| 796 | .9009181 | .9009676 | .9010222 | .9010767 | .9011313 | .9011858 | .9012403 | .9012948 | .9013493 | .9014038 | 545   |
| 797 | .9014583 | .9015128 | .9015673 | .9016218 | .9016762 | .9017307 | .9017851 | .9018396 | .9018940 | .9019485 | 545   |
| 798 | .9020029 | .9020573 | .9021117 | .9021661 | .9022205 | .9022749 | .9023293 | .9023837 | .9024381 | .9024924 | 544   |
| 799 | .9025468 | .9026011 | .9026555 | .9027098 | .9027641 | .9028185 | .9028728 | .9029271 | .9029814 | .9030357 | 543   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 800 | .9030900 | .9031443 | .9031985 | .9032528 | .9033071 | .9033613 | .9034156 | .9034698 | .9035241 | .9035783 | 542   |
| 801 | .9036325 | .9036867 | .9037409 | .9037951 | .9038493 | .9039035 | .9039577 | .9040119 | .9040661 | .9041202 | 542   |
| 802 | .9041744 | .9042285 | .9042827 | .9043368 | .9043909 | .9044450 | .9044992 | .9045533 | .9046074 | .9046615 | 541   |
| 803 | .9047155 | .9047696 | .9048237 | .9048778 | .9049318 | .9049859 | .9050399 | .9050940 | .9051480 | .9052020 | 540   |
| 804 | .9052560 | .9053101 | .9053641 | .9054181 | .9054721 | .9055260 | .9055800 | .9056340 | .9056880 | .9057419 | 539   |
| 805 | .9057959 | .9058498 | .9059038 | .9059577 | .9060116 | .9060655 | .9061195 | .9061734 | .9062273 | .9062812 | 539   |
| 806 | .9063350 | .9063889 | .9064428 | .9064967 | .9065505 | .9066044 | .9066582 | .9067121 | .9067659 | .9068197 | 538   |
| 807 | .9068735 | .9069273 | .9069812 | .9070350 | .9070887 | .9071425 | .9071963 | .9072501 | .9073038 | .9073576 | 537   |
| 808 | .9074114 | .9074651 | .9075188 | .9075726 | .9076263 | .9076800 | .9077337 | .9077874 | .9078411 | .9078948 | 537   |
| 809 | .9079485 | .9080022 | .9080559 | .9081095 | .9081632 | .9082169 | .9082705 | .9083241 | .9083778 | .9084314 | 536   |
| 810 | .9084850 | .9085386 | .9085922 | .9086458 | .9086994 | .9087530 | .9088066 | .9088602 | .9089137 | .9089673 | 536   |
| 811 | .9090209 | .9090744 | .9091279 | .9091815 | .9092350 | .9092885 | .9093420 | .9093955 | .9094490 | .9095025 | 535   |
| 812 | .9095560 | .9096095 | .9096630 | .9097165 | .9097699 | .9098234 | .9098768 | .9099303 | .9099837 | .9100371 | 534   |
| 813 | .9100905 | .9101440 | .9101974 | .9102508 | .9103042 | .9103576 | .9104109 | .9104643 | .9105177 | .9105710 | 534   |
| 814 | .9106244 | .9106778 | .9107311 | .9107844 | .9108378 | .9108911 | .9109444 | .9109977 | .9110510 | .9111043 | 533   |
| 815 | .9111576 | .9112109 | .9112642 | .9113174 | .9113707 | .9114240 | .9114772 | .9115305 | .9115837 | .9116369 | 533   |
| 816 | .9116902 | .9117434 | .9117966 | .9118498 | .9119030 | .9119562 | .9120094 | .9120626 | .9121157 | .9121689 | 532   |
| 817 | .9122221 | .9122752 | .9123284 | .9123815 | .9124346 | .9124878 | .9125409 | .9125940 | .9126471 | .9127002 | 531   |
| 818 | .9127533 | .9128064 | .9128595 | .9129126 | .9129656 | .9130187 | .9130717 | .9131248 | .9131778 | .9132309 | 531   |
| 819 | .9132839 | .9133369 | .9133899 | .9134430 | .9134960 | .9135490 | .9136019 | .9136549 | .9137079 | .9137609 | 530   |
| 820 | .9138139 | .9138668 | .9139198 | .9139727 | .9140257 | .9140786 | .9141315 | .9141844 | .9142373 | .9142903 | 530   |
| 821 | .9143432 | .9143961 | .9144489 | .9145018 | .9145547 | .9146076 | .9146604 | .9147133 | .9147661 | .9148190 | 529   |
| 822 | .9148718 | .9149246 | .9149775 | .9150303 | .9150831 | .9151359 | .9151887 | .9152415 | .9152943 | .9153471 | 528   |
| 823 | .9153998 | .9154526 | .9155054 | .9155581 | .9156109 | .9156636 | .9157163 | .9157691 | .9158218 | .9158745 | 527   |
| 824 | .9159272 | .9159799 | .9160326 | .9160853 | .9161380 | .9161907 | .9162433 | .9162960 | .9163487 | .9164013 | 526   |
| Σ.  | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 825 | .9164539 | .9165066 | .9165592 | .9166118 | .9166645 | .9167171 | .9167697 | .9168223 | .9168749 | .9169275 | 526   |
| 826 | .9169800 | .9170326 | .9170852 | .9171378 | .9171903 | .9172429 | .9172954 | .9173479 | .9174005 | .9174530 | 526   |
| 827 | .9175055 | .9175580 | .9176105 | .9176630 | .9177155 | .9177680 | .9178205 | .9178730 | .9179254 | .9179779 | 525   |
| 828 | .9180303 | .9180828 | .9181352 | .9181877 | .9182401 | .9182925 | .9183449 | .9183973 | .9184497 | .9185021 | 524   |
| 829 | .9185545 | .9186069 | .9186593 | .9187117 | .9187640 | .9188164 | .9188687 | .9189211 | .9189734 | .9190258 | 523   |
| 830 | .9190781 | .9191304 | .9191827 | .9192350 | .9192873 | .9193396 | .9193919 | .9194442 | .9194965 | .9195488 | 523   |
| 831 | .9196010 | .9196533 | .9197055 | .9197578 | .9198100 | .9198623 | .9199145 | .9199667 | .9200189 | .9200711 | 522   |
| 832 | .9201233 | .9201755 | .9202277 | .9202799 | .9203321 | .9203842 | .9204364 | .9204886 | .9205407 | .9205929 | 522   |
| 833 | .9206450 | .9206971 | .9207493 | .9208014 | .9208535 | .9209056 | .9209577 | .9210098 | .9210619 | .9211140 | 521   |
| 834 | .9211661 | .9212181 | .9212702 | .9213222 | .9213743 | .9214263 | .9214784 | .9215304 | .9215824 | .9216345 | 521   |
| 835 | .9216865 | .9217385 | .9217905 | .9218425 | .9218945 | .9219465 | .9219984 | .9220504 | .9221024 | .9221543 | 520   |
| 836 | .9222063 | .9222582 | .9223102 | .9223621 | .9224140 | .9224659 | .9225179 | .9225698 | .9226217 | .9226736 | 519   |
| 837 | .9227255 | .9227773 | .9228292 | .9228811 | .9229330 | .9229848 | .9230367 | .9230885 | .9231404 | .9231922 | 519   |
| 838 | .9232440 | .9232958 | .9233477 | .9233995 | .9234513 | .9235031 | .9235549 | .9236066 | .9236584 | .9237102 | 518   |
| 839 | .9237620 | .9238137 | .9238655 | .9239172 | .9239690 | .9240207 | .9240724 | .9241242 | .9241759 | .9242276 | 517   |
| 840 | .9242793 | .9243310 | .9243827 | .9244344 | .9244860 | .9245377 | .9245894 | .9246410 | .9246927 | .9247444 | 517   |
| 841 | .9247960 | .9248476 | .9248993 | .9249509 | .9250025 | .9250541 | .9251057 | .9251573 | .9252089 | .9252605 | 516   |
| 842 | .9253121 | .9253637 | .9254152 | .9254668 | .9255184 | .9255699 | .9256215 | .9256730 | .9257245 | .9257761 | 515   |
| 843 | .9258276 | .9258791 | .9259306 | .9259821 | .9260336 | .9260851 | .9261366 | .9261880 | .9262395 | .9262910 | 515   |
| 844 | .9263424 | .9263939 | .9264453 | .9264968 | .9265482 | .9265997 | .9266511 | .9267025 | .9267539 | .9268053 | 514   |
| 845 | .9268567 | .9269081 | .9269595 | .9270109 | .9270622 | .9271136 | .9271650 | .9272163 | .9272677 | .9273190 | 514   |
| 846 | .9273704 | .9274217 | .9274730 | .9275243 | .9275757 | .9276270 | .9276783 | .9277296 | .9277808 | .9278321 | 513   |
| 847 | .9278834 | .9279347 | .9279859 | .9280372 | .9280885 | .9281397 | .9281909 | .9282422 | .9282934 | .9283446 | 512   |
| 848 | .9283959 | .9284471 | .9284983 | .9285495 | .9286007 | .9286518 | .9287030 | .9287542 | .9288054 | .9288565 | 512   |
| 849 | .9289077 | .9289588 | .9290100 | .9290611 | .9291123 | .9291634 | .9292145 | .9292656 | .9293167 | .9293678 | 511   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 850 | .9294189 | .9294700 | .9295211 | .9295722 | .9296233 | .9296743 | .9297254 | .9297764 | .9298275 | .9298785 | 511   |
| 851 | .9299296 | .9299806 | .9300316 | .9300826 | .9301336 | .9301847 | .9302357 | .9302866 | .9303376 | .9303886 | 511   |
| 852 | .9304396 | .9304906 | .9305415 | .9305925 | .9306434 | .9306944 | .9307453 | .9307963 | .9308472 | .9308981 | 510   |
| 853 | .9309490 | .9309999 | .9310508 | .9311017 | .9311526 | .9312035 | .9312544 | .9313053 | .9313562 | .9314070 | 509   |
| 854 | .9314579 | .9315087 | .9315596 | .9316104 | .9316612 | .9317121 | .9317629 | .9318137 | .9318645 | .9319153 | 509   |
| 855 | .9319661 | .9320169 | .9320677 | .9321185 | .9321692 | .9322200 | .9322708 | .9323215 | .9323723 | .9324230 | 508   |
| 856 | .9324738 | .9325245 | .9325752 | .9326259 | .9326767 | .9327274 | .9327781 | .9328288 | .9328795 | .9329301 | 507   |
| 857 | .9329808 | .9330315 | .9330822 | .9331328 | .9331835 | .9332341 | .9332848 | .9333354 | .9333860 | .9334367 | 507   |
| 858 | .9334873 | .9335379 | .9335885 | .9336391 | .9336897 | .9337403 | .9337909 | .9338415 | .9338920 | .9339426 | 506   |
| 859 | .9339932 | .9340437 | .9340943 | .9341448 | .9341953 | .9342459 | .9342964 | .9343469 | .9343974 | .9344479 | 505   |
| 860 | .9344985 | .9345489 | .9345994 | .9346499 | .9347004 | .9347509 | .9348013 | .9348518 | .9349023 | .9349527 | 505   |
| 861 | .9350032 | .9350536 | .9351040 | .9351544 | .9352049 | .9352553 | .9353057 | .9353561 | .9354065 | .9354569 | 504   |
| 862 | .9355073 | .9355576 | .9356080 | .9356584 | .9357087 | .9357591 | .9358095 | .9358598 | .9359101 | .9359605 | 503   |
| 863 | .9360108 | .9360611 | .9361114 | .9361617 | .9362120 | .9362623 | .9363126 | .9363629 | .9364132 | .9364635 | 503   |
| 864 | .9365137 | .9365640 | .9366143 | .9366645 | .9367148 | .9367650 | .9368152 | .9368655 | .9369157 | .9369659 | 502   |
| 865 | .9370161 | .9370663 | .9371165 | .9371667 | .9372169 | .9372671 | .9373172 | .9373674 | .9374176 | .9374677 | 502   |
| 866 | .9375179 | .9375680 | .9376182 | .9376683 | .9377184 | .9377686 | .9378187 | .9378688 | .9379189 | .9379690 | 501   |
| 867 | .9380191 | .9380692 | .9381193 | .9381693 | .9382194 | .9382695 | .9383195 | .9383696 | .9384196 | .9384697 | 501   |
| 868 | .9385197 | .9385698 | .9386198 | .9386698 | .9387198 | .9387698 | .9388198 | .9388698 | .9389198 | .9389698 | 500   |
| 869 | .9390198 | .9390697 | .9391197 | .9391697 | .9392196 | .9392696 | .9393195 | .9393695 | .9394194 | .9394693 | 500   |
| 870 | .9395193 | .9395692 | .9396191 | .9396690 | .9397189 | .9397688 | .9398187 | .9398685 | .9399184 | .9399683 | 499   |
| 871 | .9400182 | .9400680 | .9401179 | .9401677 | .9402176 | .9402674 | .9403172 | .9403670 | .9404169 | .9404667 | 498   |
| 872 | .9405165 | .9405663 | .9406161 | .9406659 | .9407157 | .9407654 | .9408152 | .9408650 | .9409147 | .9409645 | 498   |
| 873 | .9410142 | .9410640 | .9411137 | .9411635 | .9412132 | .9412629 | .9413126 | .9413623 | .9414120 | .9414617 | 497   |
| 874 | .9415114 | .9415611 | .9416108 | .9416605 | .9417101 | .9417598 | .9418095 | .9418591 | .9419088 | .9419584 | 497   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 875 | .9420081 | .9420577 | .9421073 | .9421569 | .9422065 | .9422562 | .9423058 | .9423553 | .9424049 | .9424545 | 496   |
| 876 | .9425041 | .9425537 | .9426032 | .9426528 | .9427024 | .9427519 | .9428015 | .9428510 | .9429005 | .9429501 | 495   |
| 877 | .9429996 | .9430491 | .9430986 | .9431481 | .9431976 | .9432471 | .9432966 | .9433461 | .9433956 | .9434450 | 495   |
| 878 | .9434945 | .9435440 | .9435934 | .9436429 | .9436923 | .9437418 | .9437912 | .9438406 | .9438900 | .9439395 | 494   |
| 879 | .9439889 | .9440383 | .9440877 | .9441371 | .9441865 | .9442358 | .9442852 | .9443346 | .9443840 | .9444333 | 494   |
| 880 | .9444827 | .9445320 | .9445814 | .9446307 | .9446800 | .9447294 | .9447787 | .9448280 | .9448773 | .9449266 | 493   |
| 881 | .9449759 | .9450252 | .9450745 | .9451238 | .9451730 | .9452223 | .9452716 | .9453208 | .9453701 | .9454193 | 492   |
| 882 | .9454686 | .9455178 | .9455671 | .9456163 | .9456655 | .9457147 | .9457639 | .9458131 | .9458623 | .9459115 | 492   |
| 883 | .9459607 | .9460099 | .9460591 | .9461082 | .9461574 | .9462066 | .9462557 | .9463049 | .9463540 | .9464031 | 491   |
| 884 | .9464523 | .9465014 | .9465505 | .9465996 | .9466487 | .9466978 | .9467469 | .9467960 | .9468451 | .9468942 | 491   |
| 885 | .9469433 | .9469923 | .9470414 | .9470905 | .9471395 | .9471886 | .9472376 | .9472866 | .9473357 | .9473847 | 490   |
| 886 | .9474337 | .9474827 | .9475317 | .9475807 | .9476297 | .9476787 | .9477277 | .9477767 | .9478257 | .9478747 | 490   |
| 887 | .9479236 | .9479726 | .9480215 | .9480705 | .9481194 | .9481684 | .9482173 | .9482662 | .9483151 | .9483641 | 489   |
| 888 | .9484130 | .9484619 | .9485108 | .9485597 | .9486085 | .9486574 | .9487063 | .9487552 | .9488040 | .9488529 | 489   |
| 889 | .9489018 | .9489506 | .9489995 | .9490483 | .9490971 | .9491460 | .9491948 | .9492436 | .9492924 | .9493412 | 488   |
| 890 | .9493900 | .9494388 | .9494876 | .9495364 | .9495852 | .9496339 | .9496827 | .9497315 | .9497802 | .9498290 | 488   |
| 891 | .9498777 | .9499264 | .9499752 | .9500239 | .9500726 | .9501213 | .9501701 | .9502188 | .9502675 | .9503162 | 487   |
| 892 | .9503649 | .9504135 | .9504622 | .9505109 | .9505596 | .9506082 | .9506569 | .9507055 | .9507542 | .9508028 | 487   |
| 893 | .9508515 | .9509001 | .9509487 | .9509973 | .9510459 | .9510946 | .9511432 | .9511918 | .9512404 | .9512889 | 486   |
| 894 | .9513375 | .9513861 | .9514347 | .9514832 | .9515318 | .9515803 | .9516289 | .9516774 | .9517260 | .9517745 | 486   |
| 895 | .9518230 | .9518716 | .9519201 | .9519686 | .9520171 | .9520656 | .9521141 | .9521626 | .9522111 | .9522595 | 485   |
| 896 | .9523080 | .9523565 | .9524049 | .9524534 | .9525018 | .9525503 | .9525987 | .9526472 | .9526956 | .9527440 | 485   |
| 897 | .9527924 | .9528409 | .9528893 | .9529377 | .9529861 | .9530345 | .9530828 | .9531312 | .9531796 | .9532280 | 484   |
| 898 | .9532763 | .9533247 | .9533731 | .9534214 | .9534697 | .9535181 | .9535664 | .9536147 | .9536631 | .9537114 | 483   |
| 899 | .9537597 | .9538080 | .9538563 | .9539046 | .9539529 | .9540012 | .9540494 | .9540977 | .9541460 | .9541943 | 483   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0       | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diff. |
|-----|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| 900 | 9542425 | 9542908 | 9543390 | 9543873 | 9544355 | 9544837 | 9545319 | 9545802 | 9546284 | 9546766 | 482   |
| 901 | 9547248 | 9547730 | 9548212 | 9548694 | 9549176 | 9549657 | 9550139 | 9550621 | 9551102 | 9551584 | 482   |
| 902 | 9552065 | 9552547 | 9553028 | 9553510 | 9553991 | 9554472 | 9554953 | 9555434 | 9555916 | 9556397 | 481   |
| 903 | 9556878 | 9557358 | 9557839 | 9558320 | 9558801 | 9559282 | 9559762 | 9560243 | 9560723 | 9561204 | 481   |
| 904 | 9561684 | 9562165 | 9562645 | 9563125 | 9563606 | 9564086 | 9564566 | 9565046 | 9565526 | 9566006 | 480   |
| 905 | 9566486 | 9566966 | 9567445 | 9567925 | 9568405 | 9568885 | 9569364 | 9569844 | 9570323 | 9570803 | 480   |
| 906 | 9571282 | 9571761 | 9572241 | 9572720 | 9573199 | 9573678 | 9574157 | 9574636 | 9575115 | 9575594 | 479   |
| 907 | 9576073 | 9576552 | 9577030 | 9577509 | 9577988 | 9578466 | 9578945 | 9579423 | 9579902 | 9580380 | 479   |
| 908 | 9580858 | 9581337 | 9581815 | 9582293 | 9582771 | 9583249 | 9583727 | 9584205 | 9584683 | 9585161 | 478   |
| 909 | 9585639 | 9586117 | 9586594 | 9587072 | 9587549 | 9588027 | 9588505 | 9588982 | 9589459 | 9589937 | 478   |
| 910 | 9590414 | 9590891 | 9591368 | 9591845 | 9592322 | 9592800 | 9593276 | 9593753 | 9594230 | 9594707 | 477   |
| 911 | 9595184 | 9595660 | 9596137 | 9596614 | 9597090 | 9597567 | 9598043 | 9598520 | 9598996 | 9599472 | 477   |
| 912 | 9599948 | 9600425 | 9600901 | 9601377 | 9601853 | 9602329 | 9602805 | 9603281 | 9603756 | 9604232 | 476   |
| 913 | 9601708 | 9603183 | 9603659 | 9604135 | 9604610 | 9605086 | 9605561 | 9606036 | 9606512 | 9606987 | 476   |
| 914 | 9609462 | 9609937 | 9610412 | 9610887 | 9611362 | 9611837 | 9612312 | 9612787 | 9613262 | 9613736 | 475   |
| 915 | 9614211 | 9614686 | 9615160 | 9615635 | 9616109 | 9616583 | 9617058 | 9617532 | 9618006 | 9618481 | 474   |
| 916 | 9618955 | 9619429 | 9619903 | 9620377 | 9620851 | 9621325 | 9621799 | 9622272 | 9622746 | 9623220 | 474   |
| 917 | 9623693 | 9624167 | 9624640 | 9625114 | 9625587 | 9626061 | 9626534 | 9627007 | 9627481 | 9627954 | 473   |
| 918 | 9628427 | 9628900 | 9629373 | 9629846 | 9630319 | 9630792 | 9631264 | 9631737 | 9632210 | 9632683 | 473   |
| 919 | 9633155 | 9633628 | 9634100 | 9634573 | 9635045 | 9635517 | 9635990 | 9636462 | 9636934 | 9637406 | 472   |
| 920 | 9637878 | 9638350 | 9638822 | 9639294 | 9639766 | 9640238 | 9640710 | 9641181 | 9641653 | 9642125 | 472   |
| 921 | 9642596 | 9643068 | 9643539 | 9644011 | 9644482 | 9644953 | 9645425 | 9645896 | 9646367 | 9646838 | 471   |
| 922 | 9647309 | 9647780 | 9648251 | 9648722 | 9649193 | 9649664 | 9650135 | 9650605 | 9651076 | 9651546 | 471   |
| 923 | 9652017 | 9652488 | 9652958 | 9653428 | 9653899 | 9654369 | 9654839 | 9655309 | 9655780 | 9656250 | 470   |
| 924 | 9656720 | 9657190 | 9657660 | 9658130 | 9658600 | 9659069 | 9659539 | 9660009 | 9660478 | 9660948 | 470   |
| No. | 0       | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 875 | .9420081 | .9420577 | .9421073 | .9421569 | .9422065 | .9422562 | .9423058 | .9423553 | .9424049 | .9424545 | 496   |
| 876 | .9425041 | .9425537 | .9426032 | .9426528 | .9427024 | .9427519 | .9428015 | .9428510 | .9429005 | .9429501 | 495   |
| 877 | .9429996 | .9430491 | .9430986 | .9431481 | .9431976 | .9432471 | .9432966 | .9433461 | .9433956 | .9434450 | 495   |
| 878 | .9434945 | .9435440 | .9435934 | .9436429 | .9436923 | .9437418 | .9437912 | .9438406 | .9438900 | .9439395 | 494   |
| 879 | .9439889 | .9440383 | .9440877 | .9441371 | .9441865 | .9442358 | .9442852 | .9443346 | .9443840 | .9444333 | 494   |
| 880 | .9444827 | .9445320 | .9445814 | .9446307 | .9446800 | .9447294 | .9447787 | .9448280 | .9448773 | .9449266 | 493   |
| 881 | .9449759 | .9450252 | .9450745 | .9451238 | .9451730 | .9452223 | .9452716 | .9453208 | .9453701 | .9454193 | 492   |
| 882 | .9454686 | .9455178 | .9455671 | .9456163 | .9456655 | .9457147 | .9457639 | .9458131 | .9458623 | .9459115 | 492   |
| 883 | .9459607 | .9460099 | .9460591 | .9461082 | .9461574 | .9462066 | .9462557 | .9463049 | .9463540 | .9464031 | 491   |
| 884 | .9464523 | .9465014 | .9465505 | .9465996 | .9466487 | .9466978 | .9467469 | .9467960 | .9468451 | .9468942 | 491   |
| 885 | .9469433 | .9469923 | .9470414 | .9470905 | .9471395 | .9471886 | .9472376 | .9472866 | .9473357 | .9473847 | 490   |
| 886 | .9474337 | .9474827 | .9475317 | .9475807 | .9476297 | .9476787 | .9477277 | .9477767 | .9478257 | .9478747 | 490   |
| 887 | .9479236 | .9479726 | .9480215 | .9480705 | .9481194 | .9481684 | .9482173 | .9482662 | .9483151 | .9483641 | 489   |
| 888 | .9484130 | .9484619 | .9485108 | .9485597 | .9486085 | .9486574 | .9487063 | .9487552 | .9488040 | .9488529 | 489   |
| 889 | .9489018 | .9489506 | .9489995 | .9490483 | .9490971 | .9491460 | .9491948 | .9492436 | .9492924 | .9493412 | 488   |
| 890 | .9493900 | .9494388 | .9494876 | .9495364 | .9495852 | .9496339 | .9496827 | .9497315 | .9497802 | .9498290 | 488   |
| 891 | .9498777 | .9499264 | .9499752 | .9500239 | .9500726 | .9501213 | .9501701 | .9502188 | .9502675 | .9503162 | 487   |
| 892 | .9503649 | .9504135 | .9504622 | .9505109 | .9505596 | .9506082 | .9506569 | .9507055 | .9507542 | .9508028 | 487   |
| 893 | .9508515 | .9509001 | .9509487 | .9509973 | .9510459 | .9510946 | .9511432 | .9511918 | .9512404 | .9512889 | 486   |
| 894 | .9513375 | .9513861 | .9514347 | .9514832 | .9515318 | .9515803 | .9516289 | .9516774 | .9517260 | .9517745 | 486   |
| 895 | .9518230 | .9518716 | .9519201 | .9519686 | .9520171 | .9520656 | .9521141 | .9521626 | .9522111 | .9522595 | 485   |
| 896 | .9523080 | .9523565 | .9524049 | .9524534 | .9525018 | .9525503 | .9525987 | .9526472 | .9526956 | .9527440 | 485   |
| 897 | .9527924 | .9528409 | .9528893 | .9529377 | .9529861 | .9530345 | .9530828 | .9531312 | .9531796 | .9532280 | 484   |
| 898 | .9532763 | .9533247 | .9533731 | .9534214 | .9534697 | .9535181 | .9535664 | .9536147 | .9536631 | .9537114 | 483   |
| 899 | .9537597 | .9538080 | .9538563 | .9539046 | .9539529 | .9540012 | .9540494 | .9540977 | .9541460 | .9541943 | 483   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |



| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 900 | .9542425 | .9542908 | .9543390 | .9543873 | .9544355 | .9544837 | .9545319 | .9545802 | .9546284 | .9546766 | 482   |
| 901 | .9547248 | .9547730 | .9548212 | .9548694 | .9549176 | .9549657 | .9550139 | .9550621 | .9551102 | .9551584 | 482   |
| 902 | .9552065 | .9552547 | .9553028 | .9553510 | .9553991 | .9554472 | .9554953 | .9555434 | .9555916 | .9556397 | 481   |
| 903 | .9556878 | .9557358 | .9557839 | .9558320 | .9558801 | .9559282 | .9559762 | .9560243 | .9560723 | .9561204 | 481   |
| 904 | .9561684 | .9562165 | .9562645 | .9563125 | .9563606 | .9564086 | .9564566 | .9565046 | .9565526 | .9566006 | 480   |
| 905 | .9566486 | .9566966 | .9567445 | .9567925 | .9568405 | .9568885 | .9569364 | .9569844 | .9570323 | .9570803 | 480   |
| 906 | .9571282 | .9571761 | .9572241 | .9572720 | .9573199 | .9573678 | .9574157 | .9574636 | .9575115 | .9575594 | 479   |
| 907 | .9576073 | .9576552 | .9577030 | .9577509 | .9577988 | .9578466 | .9578945 | .9579423 | .9579902 | .9580380 | 479   |
| 908 | .9580858 | .9581337 | .9581815 | .9582293 | .9582771 | .9583249 | .9583727 | .9584205 | .9584683 | .9585161 | 478   |
| 909 | .9585639 | .9586117 | .9586594 | .9587072 | .9587549 | .9588027 | .9588505 | .9588982 | .9589459 | .9589937 | 478   |
| 910 | .9590414 | .9590891 | .9591368 | .9591845 | .9592322 | .9592800 | .9593276 | .9593753 | .9594230 | .9594707 | 477   |
| 911 | .9595184 | .9595660 | .9596137 | .9596614 | .9597090 | .9597567 | .9598043 | .9598520 | .9598996 | .9599472 | 477   |
| 912 | .9599948 | .9600425 | .9600901 | .9601377 | .9601853 | .9602329 | .9602805 | .9603281 | .9603756 | .9604232 | 476   |
| 913 | .9604708 | .9605183 | .9605659 | .9606135 | .9606610 | .9607086 | .9607561 | .9608036 | .9608512 | .9608987 | 476   |
| 914 | .9609462 | .9609937 | .9610412 | .9610887 | .9611362 | .9611837 | .9612312 | .9612787 | .9613262 | .9613736 | 475   |
| 915 | .9614211 | .9614686 | .9615160 | .9615635 | .9616109 | .9616583 | .9617058 | .9617532 | .9618006 | .9618481 | 474   |
| 916 | .9618955 | .9619429 | .9619903 | .9620377 | .9620851 | .9621325 | .9621799 | .9622272 | .9622746 | .9623220 | 474   |
| 917 | .9623693 | .9624167 | .9624640 | .9625114 | .9625587 | .9626061 | .9626534 | .9627007 | .9627481 | .9627954 | 473   |
| 918 | .9628427 | .9628900 | .9629373 | .9629846 | .9630319 | .9630792 | .9631264 | .9631737 | .9632210 | .9632683 | 473   |
| 919 | .9633155 | .9633628 | .9634100 | .9634573 | .9635045 | .9635517 | .9635990 | .9636462 | .9636934 | .9637406 | 472   |
| 920 | .9637878 | .9638350 | .9638822 | .9639294 | .9639766 | .9640238 | .9640710 | .9641181 | .9641653 | .9642125 | 472   |
| 921 | .9642596 | .9643068 | .9643539 | .9644011 | .9644482 | .9644953 | .9645425 | .9645896 | .9646367 | .9646838 | 471   |
| 922 | .9647309 | .9647780 | .9648251 | .9648722 | .9649193 | .9649664 | .9650135 | .9650605 | .9651076 | .9651546 | 471   |
| 923 | .9652017 | .9652488 | .9652958 | .9653428 | .9653899 | .9654369 | .9654839 | .9655309 | .9655780 | .9656250 | 470   |
| 924 | .9656720 | .9657190 | .9657660 | .9658130 | .9658599 | .9659069 | .9659539 | .9660009 | .9660478 | .9660948 | 470   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |



| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 925 | .9661417 | .9661887 | .9662356 | .9662826 | .9663295 | .9663764 | .9664233 | .9664703 | .9665172 | .9665641 | 469   |
| 926 | .9666110 | .9666579 | .9667048 | .9667517 | .9667985 | .9668454 | .9668923 | .9669392 | .9669860 | .9670329 | 469   |
| 927 | .9670797 | .9671266 | .9671734 | .9672203 | .9672671 | .9673139 | .9673607 | .9674076 | .9674544 | .9675012 | 468   |
| 928 | .9675480 | .9675948 | .9676416 | .9676884 | .9677351 | .9677819 | .9678287 | .9678754 | .9679222 | .9679690 | 468   |
| 929 | .9680157 | .9680625 | .9681092 | .9681559 | .9682027 | .9682494 | .9682961 | .9683428 | .9683895 | .9684362 | 467   |
| 930 | .9684829 | .9685296 | .9685763 | .9686230 | .9686697 | .9687164 | .9687630 | .9688097 | .9688564 | .9689030 | 467   |
| 931 | .9689497 | .9689963 | .9690430 | .9690896 | .9691362 | .9691829 | .9692295 | .9692761 | .9693227 | .9693693 | 466   |
| 932 | .9694159 | .9694625 | .9695091 | .9695557 | .9696023 | .9696488 | .9696954 | .9697420 | .9697885 | .9698351 | 466   |
| 933 | .9698816 | .9699282 | .9699747 | .9700213 | .9700678 | .9701143 | .9701608 | .9702074 | .9702539 | .9703004 | 465   |
| 934 | .9703469 | .9703934 | .9704399 | .9704863 | .9705328 | .9705793 | .9706258 | .9706722 | .9707187 | .9707652 | 465   |
| 935 | .9708116 | .9708581 | .9709045 | .9709509 | .9709974 | .9710438 | .9710902 | .9711366 | .9711830 | .9712294 | 464   |
| 936 | .9712758 | .9713222 | .9713686 | .9714150 | .9714614 | .9715078 | .9715542 | .9716005 | .9716469 | .9716932 | 464   |
| 937 | .9717396 | .9717859 | .9718323 | .9718786 | .9719249 | .9719713 | .9720176 | .9720639 | .9721102 | .9721565 | 463   |
| 938 | .9722028 | .9722491 | .9722954 | .9723417 | .9723880 | .9724343 | .9724805 | .9725268 | .9725731 | .9726193 | 463   |
| 939 | .9726656 | .9727118 | .9727581 | .9728043 | .9728506 | .9728968 | .9729430 | .9729892 | .9730354 | .9730816 | 462   |
| 940 | .9731279 | .9731741 | .9732202 | .9732664 | .9733126 | .9733588 | .9734050 | .9734511 | .9734973 | .9735435 | 462   |
| 941 | .9735896 | .9736358 | .9736819 | .9737281 | .9737742 | .9738203 | .9738664 | .9739126 | .9739587 | .9740048 | 461   |
| 942 | .9740509 | .9740970 | .9741431 | .9741892 | .9742353 | .9742814 | .9743274 | .9743735 | .9744196 | .9744656 | 461   |
| 943 | .9745117 | .9745577 | .9746038 | .9746498 | .9746959 | .9747419 | .9747879 | .9748340 | .9748800 | .9749260 | 460   |
| 944 | .9749720 | .9750180 | .9750640 | .9751100 | .9751560 | .9752020 | .9752479 | .9752939 | .9753399 | .9753858 | 460   |
| 945 | .9754318 | .9754778 | .9755237 | .9755697 | .9756156 | .9756615 | .9757075 | .9757534 | .9757993 | .9758452 | 459   |
| 946 | .9758911 | .9759370 | .9759829 | .9760288 | .9760747 | .9761206 | .9761665 | .9762124 | .9762582 | .9763041 | 459   |
| 947 | .9763500 | .9763958 | .9764417 | .9764875 | .9765334 | .9765792 | .9766251 | .9766709 | .9767167 | .9767625 | 458   |
| 948 | .9768083 | .9768541 | .9769000 | .9769458 | .9769915 | .9770373 | .9770831 | .9771289 | .9771747 | .9772204 | 458   |
| 949 | .9772662 | .9773120 | .9773577 | .9774035 | .9774492 | .9774950 | .9775407 | .9775864 | .9776322 | .9776779 | 457   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 950 | .9777236 | .9777693 | .9778150 | .9778607 | .9779064 | .9779521 | .9779978 | .9780435 | .9780892 | .9781348 | 457   |
| 951 | .9781805 | .9782262 | .9782718 | .9783175 | .9783631 | .9784088 | .9784544 | .9785001 | .9785457 | .9785913 | 456   |
| 952 | .9786369 | .9786826 | .9787282 | .9787738 | .9788194 | .9788650 | .9789106 | .9789562 | .9790017 | .9790473 | 456   |
| 953 | .9790929 | .9791385 | .9791840 | .9792296 | .9792751 | .9793207 | .9793662 | .9794118 | .9794573 | .9795028 | 455   |
| 954 | .9795484 | .9795939 | .9796394 | .9796849 | .9797304 | .9797759 | .9798214 | .9798669 | .9799124 | .9799579 | 455   |
| 955 | .9800034 | .9800488 | .9800943 | .9801398 | .9801852 | .9802307 | .9802761 | .9803216 | .9803670 | .9804125 | 454   |
| 956 | .9804579 | .9805033 | .9805487 | .9805942 | .9806396 | .9806850 | .9807304 | .9807758 | .9808212 | .9808666 | 454   |
| 957 | .9809119 | .9809573 | .9810027 | .9810481 | .9810934 | .9811388 | .9811841 | .9812295 | .9812748 | .9813202 | 453   |
| 958 | .9813655 | .9814108 | .9814562 | .9815015 | .9815468 | .9815921 | .9816374 | .9816827 | .9817280 | .9817733 | 453   |
| 959 | .9818186 | .9818639 | .9819092 | .9819544 | .9819997 | .9820450 | .9820902 | .9821355 | .9821807 | .9822260 | 453   |
| 960 | .9822712 | .9823165 | .9823617 | .9824069 | .9824522 | .9824974 | .9825426 | .9825878 | .9826330 | .9826782 | 452   |
| 961 | .9827234 | .9827686 | .9828138 | .9828589 | .9829041 | .9829493 | .9829945 | .9830396 | .9830848 | .9831299 | 452   |
| 962 | .9831751 | .9832202 | .9832654 | .9833105 | .9833556 | .9834007 | .9834459 | .9834910 | .9835361 | .9835812 | 451   |
| 963 | .9836263 | .9836714 | .9837165 | .9837616 | .9838066 | .9838517 | .9838968 | .9839419 | .9839869 | .9840320 | 451   |
| 964 | .9840770 | .9841221 | .9841671 | .9842122 | .9842572 | .9843022 | .9843473 | .9843923 | .9844373 | .9844823 | 450   |
| 965 | .9845273 | .9845723 | .9846173 | .9846623 | .9847073 | .9847523 | .9847973 | .9848422 | .9848872 | .9849322 | 450   |
| 966 | .9849771 | .9850221 | .9850670 | .9851120 | .9851569 | .9852019 | .9852468 | .9852917 | .9853366 | .9853816 | 449   |
| 967 | .9854265 | .9854714 | .9855163 | .9855612 | .9856061 | .9856510 | .9856959 | .9857407 | .9857856 | .9858305 | 449   |
| 968 | .9858754 | .9859202 | .9859651 | .9860099 | .9860548 | .9860996 | .9861445 | .9861893 | .9862341 | .9862790 | 448   |
| 969 | .9863238 | .9863686 | .9864134 | .9864582 | .9865030 | .9865478 | .9865926 | .9866374 | .9866822 | .9867270 | 448   |
| 970 | .9867717 | .9868165 | .9868613 | .9869060 | .9869508 | .9869955 | .9870403 | .9870850 | .9871298 | .9871745 | 447   |
| 971 | .9872192 | .9872640 | .9873087 | .9873534 | .9873981 | .9874428 | .9874875 | .9875322 | .9875769 | .9876216 | 447   |
| 972 | .9876663 | .9877109 | .9877556 | .9878003 | .9878450 | .9878896 | .9879343 | .9879789 | .9880236 | .9880682 | 446   |
| 973 | .9881128 | .9881575 | .9882021 | .9882467 | .9882913 | .9883360 | .9883806 | .9884252 | .9884698 | .9885144 | 446   |
| 974 | .9885590 | .9886035 | .9886481 | .9886927 | .9887373 | .9887818 | .9888264 | .9888710 | .9889155 | .9889601 | 445   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |
|-----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| 975 | .9890046 | .9890492 | .9890937 | .9891382 | .9891828 | .9892273 | .9892718 | .9893163 | .9893608 | .9894053 | 445   |
| 976 | .9894498 | .9894943 | .9895388 | .9895833 | .9896278 | .9896722 | .9897167 | .9897612 | .9898057 | .9898501 | 444   |
| 977 | .9898946 | .9899390 | .9899835 | .9900279 | .9900723 | .9901168 | .9901612 | .9902056 | .9902500 | .9902944 | 444   |
| 978 | .9903389 | .9903833 | .9904277 | .9904721 | .9905164 | .9905608 | .9906052 | .9906496 | .9906940 | .9907383 | 444   |
| 979 | .9907827 | .9908271 | .9908714 | .9909158 | .9909601 | .9910044 | .9910488 | .9910931 | .9911374 | .9911818 | 443   |
| 980 | .9912261 | .9912704 | .9913147 | .9913590 | .9914033 | .9914476 | .9914919 | .9915362 | .9915805 | .9916247 | 443   |
| 981 | .9916690 | .9917133 | .9917575 | .9918018 | .9918461 | .9918903 | .9919345 | .9919788 | .9920230 | .9920673 | 442   |
| 982 | .9921115 | .9921557 | .9921999 | .9922441 | .9922884 | .9923326 | .9923768 | .9924210 | .9924651 | .9925093 | 442   |
| 983 | .9925535 | .9925977 | .9926419 | .9926860 | .9927302 | .9927744 | .9928185 | .9928627 | .9929068 | .9929510 | 441   |
| 984 | .9929951 | .9930392 | .9930834 | .9931275 | .9931716 | .9932157 | .9932598 | .9933039 | .9933480 | .9933921 | 441   |
| 985 | .9934362 | .9934803 | .9935244 | .9935685 | .9936126 | .9936566 | .9937007 | .9937448 | .9937888 | .9938329 | 441   |
| 986 | .9938769 | .9939210 | .9939650 | .9940090 | .9940531 | .9940971 | .9941411 | .9941851 | .9942291 | .9942731 | 440   |
| 987 | .9943172 | .9943612 | .9944051 | .9944491 | .9944931 | .9945371 | .9945811 | .9946251 | .9946690 | .9947130 | 440   |
| 988 | .9947569 | .9948009 | .9948448 | .9948888 | .9949327 | .9949767 | .9950206 | .9950645 | .9951085 | .9951524 | 439   |
| 989 | .9951963 | .9952402 | .9952841 | .9953280 | .9953719 | .9954158 | .9954597 | .9955036 | .9955474 | .9955913 | 439   |
| 990 | .9956352 | .9956791 | .9957229 | .9957668 | .9958106 | .9958545 | .9958983 | .9959422 | .9959860 | .9960298 | 438   |
| 991 | .9960737 | .9961175 | .9961613 | .9962051 | .9962489 | .9962927 | .9963365 | .9963803 | .9964241 | .9964679 | 438   |
| 992 | .9965117 | .9965554 | .9965992 | .9966430 | .9966868 | .9967305 | .9967743 | .9968180 | .9968618 | .9969055 | 438   |
| 993 | .9969492 | .9969930 | .9970367 | .9970804 | .9971242 | .9971679 | .9972116 | .9972553 | .9972990 | .9973427 | 437   |
| 994 | .9973864 | .9974301 | .9974738 | .9975174 | .9975611 | .9976048 | .9976485 | .9976921 | .9977358 | .9977794 | 437   |
| 995 | .9978231 | .9978667 | .9979104 | .9979540 | .9979976 | .9980413 | .9980849 | .9981285 | .9981721 | .9982157 | 436   |
| 996 | .9982593 | .9983029 | .9983465 | .9983901 | .9984337 | .9984773 | .9985209 | .9985645 | .9986080 | .9986516 | 436   |
| 997 | .9986952 | .9987387 | .9987823 | .9988258 | .9988694 | .9989129 | .9989564 | .9990000 | .9990435 | .9990870 | 435   |
| 998 | .9991305 | .9991741 | .9992176 | .9992611 | .9993046 | .9993481 | .9993916 | .9994350 | .9994785 | .9995220 | 435   |
| 999 | .9995655 | .9996090 | .9996524 | .9996959 | .9997393 | .9997828 | .9998262 | .9998697 | .9999131 | .9999566 | 435   |
| No. | 0        | 1        | 2        | 3        | 4        | 5        | 6        | 7        | 8        | 9        | Diff. |

## STRENGTH OF MATERIALS.

## DEFINITIONS.

1. *Direct extensibility* or *compressibility* is the amount of direct strain produced by each pound on the square inch of direct stress.

2. *Direct pliability* includes both of the terms 'direct extensibility' and 'direct compressibility.'

3. *Elasticity* is that property of a body by which it tends to occupy a determinate bulk and figure at a given pressure and temperature.

4. *Elastic strength* is the utmost amount of stress which a body can bear without set.

5. *Factors of safety* are of three kinds—

I. The ratio in which the breaking load exceeds the proof load.

II. The ratio in which the breaking load exceeds the working load.

III. The ratio in which the proof load exceeds the working load.

6. *Modulus of elasticity* is the reciprocal of the direct pliability when the stress does not exceed the proof strength.

7. *Pliability* is the inverse of stiffness, and is measured by the quantity of strain produced by a certain fixed stress.

8. *Proof strain* is the utmost strain which a body can bear without injury.

9. *Proof strength* or *proof stress* is the utmost stress which a body can bear without suffering any diminution of stiffness or strength.

10. *Proof load* is the load which produces the proof stress.

11. *Set* is the permanent strain or alteration of shape which remains in an imperfectly elastic body after a stress has been removed.

12. *Spring* or *resilience* is the quantity of work which is required to produce the proof strain, and is one-half of the product of the proof strength of the body by its proof strain.

13. *Stiffness* is measured by the intensity of the stress required to produce a certain fixed quantity of strain.

14. *Strain* is the measure of the alteration of the shape of a body, corresponding to a given stress.

15. *Strength* or *ultimate strength* is the utmost amount of stress which a body can bear without breaking.

16. *Stress* is the intensity of a load which tends to alter the

shape of a body, and it is also the equal and opposite resistance offered by the body to its load.

17. *Ultimate strain* is the utmost strain or alteration of shape which a body can bear without breaking.

18. *Working strength* is the utmost strength to which it is considered safe to subject a body during its ordinary use as part of a structure.

19. *Working load* is the load which produces the working stress.

#### NOTES ON THE STRENGTH, &c., OF MATERIALS.

(From '*Ship-building, Theoretical and Practical*.')

1. The tenacity of wrought iron and puddled steel is greater in the direction in which they are rolled than in the direction of their breadth, but in cast steel it is the reverse.

TABLE OF THE CONDITIONS IN WHICH IRON IS FOUND IN ITS ORES.

| Oxides of Iron  |   | By<br>Chemical<br>Equi-<br>valents* | By<br>Weight | Per-<br>centage<br>of Iron |
|---|---|-------------------------------------|--------------|----------------------------|
| Native iron is nearly pure, or combined with one-fourth to one-hundredth part of its weight of nickel . . . . . |   | —                                   | —            | 80 to 100                  |
| Protoxide or black oxide of iron . . . . .  | iron . . . . .                            | 3                                   | 56           | 72                         |
|   | oxygen . . . . .                          | 1                                   | 16           |                            |
| Peroxide or red oxide of iron . . . . .   | iron . . . . .                            | 4                                   | 112          | 160                        |
|   | oxygen . . . . .                          | 3                                   | 48           |                            |
| Magnetic oxide of iron . . . . .  | iron . . . . .                            | 3                                   | 84           | 116                        |
|   | oxygen . . . . .                          | 2                                   | 32           |                            |
| Hydrate of peroxide of iron . . . . .   | peroxide of iron, 2 equivalents . . . . . | 3                                   | 224          | 374                        |
|   | water, 3 equivalents . . . . .            | 6                                   | 144          |                            |
|   | hydrog. . . . .                           | 3                                   | 6            |                            |
|   | iron . . . . .                            | 3                                   | 56           |                            |
| Carbonate of iron . . . . .   | protoxide of iron, 1 equivalent . . . . . | 1                                   | 48           | 116                        |
|   | oxygen . . . . .                          | 1                                   | 16           |                            |
|   | carbonic acid, 1 equivalent . . . . .     | 2                                   | 12           |                            |
|   | carbon . . . . .                          | 2                                   | 12           |                            |

2. *Brown iron ore* is hydrate of peroxide of iron nearly pure or mixed. When nearly pure and compact it is called *brown hematite*; when earthy and mixed with clay, *yellow ochre*.

3. *Carbonate of iron*, when pure and crystallised, is called *sparry iron ore*, or *spathose iron ore*; when mixed with clay and sand, *clay ironstone*. When *clay ironstone* is coloured black by carbonaceous matter it is called *black-band ironstone*.

\* The chemical equivalents adopted in the above table are as follows:—oxygen, 16; carbon, 6; hydrogen, 1; iron, 23.

4. *Magnetic iron ore* consists of magnetic oxide of iron, and contains about 72 per cent. of iron.

5. *Red iron ore* is *peroxide of iron* pure or mixed. When pure and crystalline it is called *specular iron ore*, or *iron glance*; when pure or nearly so, and in kidney-shaped masses showing a fibrous structure, it is called *red hematite*; when mixed with more or less clay and sand it is called *red ironstone* and *red ochre*.

6. The strength of iron depends mainly upon the absence of impurities, such as sulphur, calcium, and magnesium, which make it brittle at high temperatures, while silicon makes it brittle at low temperatures.

7. *Cold-blast iron* is stronger than hot-blast.

8. Annealing cast iron diminishes its tensile strength.

9. The strength of cast iron to resist crushing or cross-breaking is increased by repeated meltings, but after the twelfth melting the resistance to cross-breaking begins to diminish.

10. Good cast iron should show a good, clear skin, with regular faces and sharp angles, and when broken the surface of fracture should be of a light bluish-grey colour and close-grained texture with a uniform metallic lustre.

11. Cast iron becomes more compact and sound when cast under pressure.

12. Strength and toughness of bar iron are indicated by a fine, close, and uniform fibrous structure, free from all appearance of crystallisation, with a clear bluish-grey colour and silky lustre on a torn surface where the fibres are shown.

13. Wrought iron has its longitudinal tenacity increased by rolling.

14. The tenacity of ordinary boiler plate is not appreciably diminished at a temperature of 395° Fahrenheit, but at a dull red heat it is diminished to about three-fourths, and the tenacity of good rivet iron increases with elevation of temperature up to about 320° Fahrenheit, at which point it is one-third greater than at ordinary atmospheric temperature.

15. Wrought iron should not be used in ship-building which will not bear a tensile strain of 20 tons per square inch.

16. The tensile strain for wrought iron should not exceed  $\frac{1}{2}$  or  $\frac{1}{4}$  of the breaking weight.

17. Steel is made by adding carbon to malleable iron or by abstracting carbon from cast iron.

18. The hardness and toughness of steel is increased by being hardened in oil, but its strength is reduced by being hardened in water.

19. The tearing strain of steel rivets is about one-fourth less than their tensile strength.

20. Case-hardening bolts weakens them.

21. *Bessemer steel* is made by blowing jets of air into molten pig iron and stopping the process at the instant when the proper amount of carbon remains in the iron, or else the blast is continued until all the carbon is removed, and then the proper amount of carbon along with manganese and silicon is added, the usual way of adding the carbon being by running into the molten pig iron a sufficient quantity of highly carbonised iron. The steel thus produced is run into ingots, which are hammered and rolled like blooms of wrought iron.

22. *Blister steel* is made by embedding bars of pure wrought iron in a layer of charcoal and subjecting them to a high temperature, or by exposing the surface of the iron to a current of carburetted hydrogen gas at a high temperature.

23. *Cast steel* is made by melting bars of blister steel in a crucible along with a small quantity of carbon and some manganese, or it may be made by melting bars of pure malleable iron with manganese and the whole quantity of carbon required to make steel.

24. *Granulated steel* is made by running melted pig iron over a wheel into a cistern of water, the lumps being then taken out and embedded in pulverised hematite or in sparry iron ore, and exposed to a sufficient temperature to cause part of the oxygen of the ore to combine with and extract the carbon from the superficial layer of each of the lumps of iron, each of which is reduced to the condition of malleable iron at the surface while its heart continues in the state of cast iron. A small quantity of malleable iron is produced by the reduction of the ore. These ingredients being melted, produce steel.

25. *Puddled steel* is made by puddling pig iron and stopping the process at the instant when the proper quantity of carbon remains; the bloom is then shingled and rolled like bar iron.

26. *Shear steel* is made by breaking bars of blister steel into lengths, and making them up into bundles or fagots, and rolling them out at a welding heat, repeating the process until a near approach to uniformity of texture and composition is obtained.

27. The ultimate elongation of really good and tough specimens of iron and steel may be taken as follows:—In

|                        |      |      |    |      |
|------------------------|------|------|----|------|
| Bar iron . . .         | from | ·15  | to | ·30. |
| Plate iron, lengthwise | „    | ·04  | „  | ·17. |
| „ crosswise            | „    | ·015 | „  | ·11. |
| Steel bars . . .       | „    | ·05  | „  | ·09. |
| „ plates . . .         | „    | ·03  | „  | ·19. |

## RESISTANCE OF THIN HOLLOW CYLINDERS AND SPHERICAL SHELLS TO BURSTING.

$P$  = bursting pressure in lbs. per square inch.

$T$  = tensile strength of material in lbs. per square inch (see tables, pp. 269, 270).

$t$  = thickness of material in inches.

$r$  = radius in inches.

*For Thin Hollow Cylinders.*

$$P = \frac{Tt}{r} \qquad t = \frac{Pr}{T}$$

*For Thin Spherical Shells.*

$$P = \frac{2Tt}{r} \qquad t = \frac{Pr}{2T}$$

## RESISTANCE OF THICK HOLLOW CYLINDERS AND SPHERICAL SHELLS TO BURSTING.

$P$  = bursting pressure in lbs. per square inch.

$T$  = tensile strength of materials in lbs. per square inch.

$R$  = external radius in inches.

$r$  = internal radius in inches.

*For Thick Hollow Cylinders.*

$$P = \frac{T(R^2 - r^2)}{R^2 + r^2} \qquad R = r \sqrt{\frac{(T + P)}{(T - P)}} \qquad r = R \sqrt{\frac{(T - P)}{(T + P)}}$$

*For Thick Spherical Shells.*

$$P = \frac{2T(R^3 - r^3)}{R^3 + 2r^3} \qquad R = r \sqrt[3]{\frac{2(T + P)}{(2T - P)}} \qquad r = R \sqrt[3]{\frac{(2T - P)}{2(T + P)}}$$

## TENACITY OF WROUGHT-IRON RIVETED JOINTS IN LBS. PER SQUARE INCH OF ENTIRE PLATE.

Double-riveted. Diameter of each hole =  $\frac{3}{10}$  of distance from centre to centre of holes = 35,700 lbs.

Single-riveted = 28,600 lbs.

## RESISTANCE OF WROUGHT-IRON TUBES TO COLLAPSING.

$P$  = collapsing pressure in lbs. per square inch.

$L$  = length of tube in inches.

$d$  = diameter in inches.

$t$  = thickness of metal in inches.

$$P = \frac{9672000t^2}{Ld}$$



RESILIENCE OF TIE BARS.

- S = proof stress.  
E = modulus of elasticity (see table, p. 269).  
A = sectional area.  
L = length.  
R = resilience of bar.  
m = modulus of resilience.

$$R = \frac{S^2AL}{2E} \qquad m = \frac{S^2}{E}$$

| TABLE OF EXAMPLES OF MODULI OF RESILIENCE. |   |                          |                          |
|--|---|--------------------------|--------------------------|
| Material                                   | Proof Stress in Lbs.<br>per Square Inch | Modulus of<br>Elasticity | Modulus of<br>Resilience |
| Bar iron                                   | 20,000                                  | 28,000,000               | 14.3                     |
| Cast „                                     | 5,500                                   | 17,000,000               | 1.8                      |
| Iron wire                                  | 30,000                                  | 25,000,000               | 36.0                     |
| Steel                                      | 36,000                                  | 28,000,000               | 46.3                     |

FACTORS OF SAFETY.

- D = dead load.  
L = live load.  
F = factor of safety for mixed live and dead load.  
B = breaking load.  
P = proof load.  
W = working load.  
K = factor of safety for dead load.  
C = factor of safety for live load.

$$F = \frac{DK + CL}{D + L} \qquad P = \frac{B}{K} \qquad B = WF$$

| TABLE OF EXAMPLES OF FACTORS OF SAFETY.              |        |        |         |              |
|--|--------|--------|---------|--------------|
| B = breaking load. P = proof load. W = working load. |        |        |         |              |
| Material   | B ÷ P  | B ÷ W  | P ÷ W   | Kind of Load |
| Strongest steel                                      | 1½     | —      | —       | —            |
| Ordinary steel and<br>Wrought iron                   | 2      | 3      | 1½      | Dead load    |
| Wrought-iron riveted<br>structures                   | 2      | 4 to 6 | 2 to 3  | Live „       |
| Cast iron  | 3      | 6      | 2       | —            |
| Timber, average                                      | 2 to 3 | 3 to 4 | 1½      | Dead load    |
|  | 3      | 6 „ 8  | 2 to 2½ | Live „       |
|  | 3      | 10     | 3½      | —            |

## RESISTANCE OF PILLARS TO CRUSHING BY BENDING.

(Rankine.)

 $P$  = breaking load of pillar in lbs. $A$  = sectional area of material in square inches. $L$  = length in feet. $r$  = least radius of gyration of cross section in feet (see following table). $k$  and  $c$  = coefficients.

$$P = \frac{kA}{1 + \frac{L^2}{cr^2}} \text{ fixed at both ends.}$$

$$P = \frac{kA}{1 + \frac{4L^2}{cr^2}} \text{ jointed at both ends.}$$

$$P = \frac{kA}{1 + \frac{16L^2}{9cr^2}} \text{ jointed at one end and fixed at the other.}$$

## VALUE OF COEFFICIENTS IN LBS. PER SQUARE INCH.

|                          | Values of $k$ . | Values of $c$ . |
|--------------------------|-----------------|-----------------|
| Malleable iron . . . . . | 36,000          | 36,000          |
| Cast iron . . . . .      | 80,000          | 6,400           |
| Dry timber . . . . .     | 7,200           | 3,000           |

TABLE OF THE VALUES OF THE SQUARE OF THE LEAST RADIUS OF GYRATION FOR SPECIAL FIGURES.










|  |   |  |
|--|---|--|
| <b>Solid Rectangle.</b><br> $R^2 = \frac{b^2}{12}$                  | <b>H Iron.</b><br> Area of flanges = $A$ .<br>Area of web = $B$ .<br>$R^2 = \frac{Ab^2}{12(A+B)}$  | <b>Angle Iron.</b><br> $R^2 = \frac{h^2 \times b^2}{12(h^2 + b^2)}$ |
| <b>Thin Hollow Rectangle.</b><br> $R^2 = \frac{h^2(h+3b)}{12(h+b)}$ | <b>Cross Iron.</b><br> $R^2 = \frac{h^2}{24}$  | <b>Round Iron.</b><br> $R^2 = \frac{d^2}{16}$                       |
| <b>Thin Hollow Square.</b><br> $R^2 = \frac{h^2}{6}$                | <b>Channel Iron.</b><br> $A$ = area of flanges.<br>$B$ = area of web.<br>$t$ = thickness of web.<br>$R^2 = \left\{ \left( \frac{2h+t}{2} \right)^2 \times \left( \frac{A}{12A+12B} \right) + \frac{AB}{4(A+B)^2} \right\}$ | <b>Tube Iron.</b><br> $R^2 = \frac{d^2}{8}$                         |

TABLE OF THE STRENGTH OF LONG COLUMNS WHOSE LENGTH EXCEEDS THIRTY TIMES THEIR DIAMETER.

$W$  = breaking weight in tons.  $L$  = length in feet.  $D$  = external diameter in inches.  $d$  = internal diameter in inches.

| Kind of Column                                    | Both Ends Rounded                            | Both Ends Flat                                  |
|---|--|---|
| Hollow cast-iron cylindrical pillars . . . . .    | $W = 13 \frac{D^{3.76} - d^{3.76}}{L^{2.7}}$ | $W = 44.34 \frac{D^{3.25} - d^{3.25}}{L^{2.7}}$ |
| Solid cast-iron cylindrical pillars . . . . .     | $W = 14.9 \frac{D^{3.76}}{L^{2.7}}$          | $W = 44.16 \frac{D^{3.25}}{L^{2.7}}$            |
| Solid wrought-iron cylindrical pillars . . . . .  | $W = 42.8 \frac{D^{3.76}}{L^2}$              | $W = 123.75 \frac{D^{3.25}}{L^2}$               |
| Solid square pillars of dry deal . . . . .        | —  | $W = 7.81 \frac{D^4}{L^2}$                      |
| Solid square pillars of dry Dantzic oak . . . . . | —  | $W = 10.95 \frac{D^4}{L^2}$                     |

## STRENGTH OF SHORT COLUMNS.

$W$  = breaking weight of long column of same diameter.

$w$  = breaking weight of short column.

$C$  = crushing force of materials in tons  $\times$  sectional area of column.

$$w = \frac{WC}{W + \frac{3}{4}C}$$

## RIVETED JOINTS.

$t$  = thickness of plate in inches.

$d$  = diameter of rivet in inches.

$p$  = pitch or distance from centre to centre of rivet.

$n$  = number of rows of rivets.

$$p = d + \frac{.7854d^2}{t}$$

$$n = \frac{(p - d)t}{.7854d^2}$$

*Note.*—Each plate is weakened by the rivet holes in the ratio

$$\frac{p - d}{p} = \frac{.7854nd}{.7854nd}$$

TABLE OF DIMENSIONS OF RIVETS GENERALLY USED.

| Thickness of Plates in Inches | Diameter of Rivets in Inches |                    |                | London                       |                               |                              |
|-------------------------------|------------------------------|--------------------|----------------|------------------------------|-------------------------------|------------------------------|
|                               | Lloyds                       | Liverpool Registry | Admiralty      | Diameter of Rivets in Inches | Length Counter-sunk in Inches | Length Snap Points in Inches |
| $\frac{5}{16}$                | $\frac{5}{8}$                | $\frac{1}{2}$      | $\frac{1}{2}$  | $\frac{5}{8}$                | $1\frac{1}{8}$                | $1\frac{1}{2}$               |
| $\frac{7}{16}$                | $\frac{5}{8}$                | $\frac{5}{8}$      | $\frac{3}{4}$  | $\frac{5}{8}$                | $1\frac{1}{8}$                | $1\frac{3}{4}$               |
| $\frac{9}{16}$                | $\frac{3}{4}$                | $\frac{12}{16}$    | $\frac{3}{4}$  | $\frac{3}{4}$                | $1\frac{1}{2}$                | 2                            |
| $\frac{11}{16}$               | $\frac{3}{4}$                | $\frac{13}{16}$    | $\frac{7}{8}$  | $\frac{7}{8}$                | $1\frac{15}{16}$              | $2\frac{3}{8}$               |
| $\frac{13}{16}$               | $\frac{7}{8}$                | $\frac{7}{8}$      | 1              | $\frac{7}{8}$                | $2\frac{3}{8}$                | $2\frac{5}{8}$               |
| $\frac{15}{16}$               | 1                            | $\frac{15}{16}$    | $1\frac{1}{8}$ | 1                            | $2\frac{1}{2}$                | $2\frac{7}{8}$               |
| 1                             | 1                            | $1\frac{1}{8}$     | $1\frac{1}{2}$ | 1                            | $2\frac{3}{4}$                | $3\frac{1}{8}$               |
|                               |                              | $1\frac{1}{8}$     | $1\frac{1}{8}$ |                              | $2\frac{7}{8}$                | $3\frac{1}{4}$               |

*Note.*—Lloyds require a spacing of  $4\frac{1}{2}$  diameters.

Liverpool Registry require a spacing of 4 diameters.

Admiralty require a spacing of  $4\frac{1}{2}$  to 5 diameters in edges and butts of bottom plating and bulkhead plating, and 5 to 6 diameters in water-tight work elsewhere.

Veritas require a spacing of 4 diameters for single-riveting and  $4\frac{1}{2}$  diameters for double-riveting.

#### NOTES ON RIVETED JOINTS.

1. A closer pitch of rivets should be adopted in single- than in double-riveted butts and in double- than in treble-riveted butts.

2. With a 4-diameter pitch the efficiency of a single-riveted butt is very small.

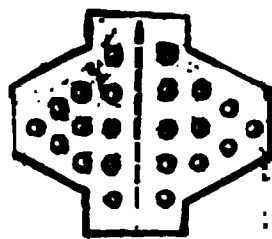
3. With a 4-diameter pitch the strength of a double-riveted butt is about at the maximum when the plates are not more than  $\frac{1}{2}$  in. thick.

4. When plates are more than  $\frac{3}{4}$  in. thick larger rivets should be put in than those generally in use.

#### BUTT STRAPS.

In joints of the character shown in the diagram the strength of the plates joined is only weakened to the extent caused by cutting away a width equal to the diameter of one rivet.

FIG. 153.



## RELATIVE TENACITY OF RIVETED JOINTS.

|                                | Rivet Holes Deducted. | Rivet Holes Included. |
|--------------------------------|-----------------------|-----------------------|
| Continuous plate . . . . .     | 100                   | 100                   |
| Double-riveted joint . . . . . | 100                   | 70                    |
| Single-riveted " . . . . .     | 79                    | 56                    |

## RESISTANCE TO SHEARING.

In plate and rivet iron the resistance is nearly equal to the tensile strength. In metals such as cast iron it is somewhat greater than the tensile strength. In timber it is nearly equal to the tenacity across the grain.

## MODULUS OF ELASTICITY.

*To Determine the Modulus of Elasticity from Extension or Compression.*

$E$  = modulus of elasticity (for values see pp. 269, 270).

$A$  = area of section in square inches.

$L$  = length of materials in feet.

$W$  = load applied in lbs. per square inch.

$l$  = elongation or compression in feet.

$$E = \frac{WL}{Al}$$

$$W = \frac{EAl}{L}$$

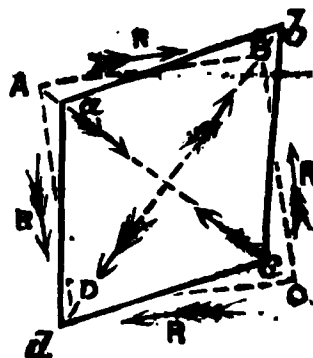
$$l = \frac{WL}{EA}$$

TABLE OF DIFFERENT KINDS OF LOAD AND STRESS.  
(Rankine.)

| LOAD AND STRESS |                            | STRAIN                   | STIFFNESS                 | PLIABILITY             | WAY OF BREAKING                 | STRENGTH                          |
|-----------------|----------------------------|--------------------------|---------------------------|------------------------|---------------------------------|-----------------------------------|
| Direct          | Pull or tension            | Stretch or extension     | Resistance to extension   | Direct extensibility   | Tearing                         | Tenacity or resistance to tearing |
|                 | Thrust or pressure         | Squeezing or compression | Resistance to compression | Direct compressibility | Crushing                        | Resistance to crushing            |
|                 | Shearing or racking stress | Racking or distortion    | Rigidity                  | Lateral pliability     | Tearing, sliding, or detraction | Resistance to shearing            |
|                 | Twisting stress            | Torsion or twisting      | Resistance to twisting    | —                      | Wrenching                       | Resistance to wrenching           |
|                 | Transverse stress          | Bending                  | Transverse stiffness      | Flexibility            | Breaking across                 | Resistance to breaking across     |
|                 | Indirect thrust            | Bending with compression | —                         | —                      | Breaking across                 | Resistance to indirect crushing   |
| Indirect        | Compound                   |                          |                           |                        |                                 |                                   |

### RACKING OR DISTORTION.

In the diagram (fig. 154) ABCD represents the original form of figure before distortion, and *abcd* represents the distorted form of ABCD.



$$\text{Distortion} = \frac{2(AC - ac)}{AC} = \frac{2(bd - BD)}{BD} \text{ sensibly.}$$

### RACKING OR SHEARING STRESS

Is that kind of stress that produces distortion, and the racking stress at the two pairs of faces of a distorted particle is of equal intensity; also every racking stress on a particle is equivalent to the combination of a tension and thrust of the same intensity acting diagonally or at an angle of  $45^\circ$  as regards the stress.

*Example* (see fig. 154).

**R** = racking stress in *n* lbs. on the square inch of surface represented by the arrows **R**.

**T** = tensile strength in *n* lbs. on the square inch acting parallel to the diagonal **BD**.

**S** = compressive strength in *n* lbs. on the square inch acting parallel to the diagonal **AC**.

$$R = T + S.$$

### TO DETERMINE THE MODULUS OF ELASTICITY FROM A RECTANGULAR BEAM SUPPORTED AT BOTH ENDS.

**L** = length of beam or distance between supports in feet.

**W** = weight in lbs.

**D** = depth of beam in inches.

**B** = breadth of beam in inches.

**d** = deflection of beam in inches.

**E** = modulus of elasticity.

$$E = \frac{WL^3}{4BD^3d}$$

$$d = \frac{WL^3}{4BD^3E}$$

### MODULUS OF RIGIDITY.

**M** = modulus of rigidity.

**R** = racking stress.

**D** = distortion.

$$M = \frac{R}{D}$$

$$R = MD$$

$$D = \frac{R}{M}$$

TABLE OF MODULI OF RIGIDITY FOR VARIOUS SUBSTANCES.

| Metals         | Modulus of Rigidity.<br>Lbs. on Sq. In. | Timber     | Modulus of Rigidity.<br>Lbs. on Sq. In. |
|----------------|---|------------|---|
| Brass wire .   | 5,330,000                               | Ash . .    | 72,000                                  |
| Copper .       | 6,200,000                               | Oak . .    | 82,000                                  |
| Cast iron .    | 2,850,000                               | Elm . .    | 76,000                                  |
| Wrought iron { | from 8,500,000<br>to 10,800,000         | Red pine { | from 62,000<br>to 116,000               |

### BENDING MOMENTS AND SHEARING FORCES OF BEAMS.

$W$  = total load.

$W'$  = additional load.

$\omega$  = intensity of uniform load.

$M$  = bending moment at any cross section.

$F$  = shearing force at any cross section.

$x$  = distance of any cross section from one end.

*Note.*—The negative signs denote downward and the positive upward forces.

#### Beams Supported at one End.

##### LOADED AT ONE END.

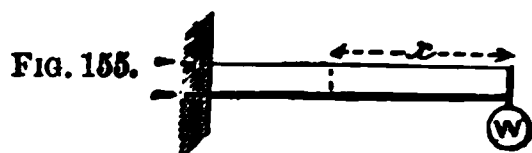


FIG. 155.

$$M = -Wx$$

$$F = -W$$

##### UNIFORMLY LOADED.

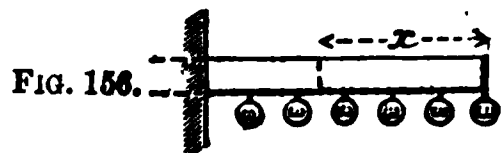


FIG. 156.

$$M = -\frac{\omega x^2}{2}$$

$$F = -\omega x$$

##### UNIFORMLY LOADED, WITH ADDITIONAL LOAD $W'$ AT ONE END.

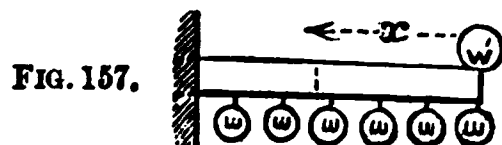


FIG. 157.

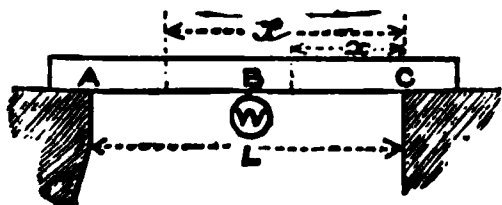
$$M = -W'x - \frac{\omega x^2}{2}$$

$$F = -W' - \omega x$$

#### Beams Supported at both Ends.

FIG. 158.

##### LOADED AT MIDDLE.



Between B and C {

$$\begin{cases} M = \frac{Wx}{2} \\ F = \frac{W}{2} \end{cases}$$

Between B and A {

$$\begin{cases} M = \frac{W(L-x)}{2} \\ F = -\frac{W}{2} \end{cases}$$

Between B and C  $\begin{cases} M = \frac{\omega(L-y)}{L} W \\ F = \frac{L-y}{L} W \end{cases}$

Between B and A  $\begin{cases} M = \frac{(L-x')}{L} y W \\ F = -\frac{Wy}{L} \end{cases}$

FIG. 159.  
LOADED AT ONE SIDE OF  
MIDDLE.

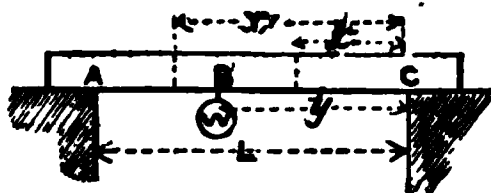


FIG. 160.  
UNIFORMLY LOADED.

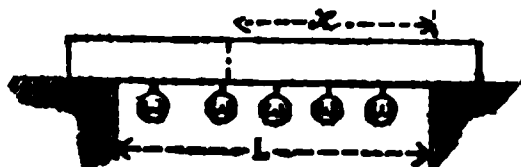
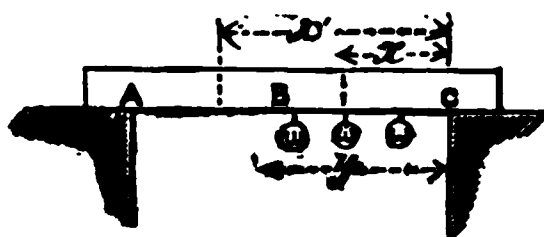


FIG. 161.  
PARTIALLY UNIFORMLY LOADED.



$$M = \frac{\omega\omega(L-\omega)}{2}$$

$$F = \omega\left(\frac{L}{2} - \omega\right)$$

Between B and C  $\begin{cases} M = \omega \left\{ \left( y - \frac{y^2}{2L} \right) x - \frac{x^2}{2} \right\} \\ F = \omega \left( y - \frac{y^2}{2L} - x \right) \end{cases}$

Between B and A  $\begin{cases} M = \frac{\omega y^2}{2L} (L - x') \\ F = -\frac{\omega y^2}{2L} \end{cases}$

TO FIND THE BENDING MOMENTS AND SHEARING FORCES  
AT ANY CROSS SECTION OF A BEAM UNEQUALLY LOADED.

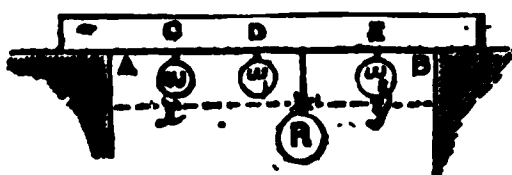
$S$  = supporting force at A.

$S'$  = supporting force at B.

$\omega, \omega_1, \omega_2$  = loads at the respective points C, D, E.

$R$  = magnitude of resultant load.

FIG. 162.



$$R = \omega + \omega_1 + \omega_2$$

$$x = \frac{(\omega \times AC) + (\omega_1 \times AD) + (\omega_2 \times AE)}{R}$$

$$S = \frac{R \times y}{x + y}$$

$$S' = \frac{R \times x}{x + y}$$

The shearing stress on any cross section (fig. 162) between AC =  $S$ , between CD =  $S - \omega$ , between DE =  $S - \omega - \omega_1$ .

*To Determine the Bending Moment at any given Loaded Point.*

**RULE.**—Multiply each shearing force by the length of the division on which it acts; the algebraical sum of the products corresponding to the divisions which lie between that point and either end of the beam will be the bending moment at the given loaded point.



## 440 MOMENT OF RESISTANCE OF BEAMS TO CROSS-BREAKING.

### Example.

*Bending moment* at  $A=0$ , at  $C=S \times AC$ , at  $D=S \times AC + (S-\omega)CD$ , at  $E=S \times AC + (S-\omega)CD + (S-\omega-\omega_1)DE$ .

*Note.*—The maximum bending moment is at  $R$ , the shearing force being zero at that point.

### MODULUS OF RUPTURE.

In a beam the *modulus of rupture* is the intensity of the stress which is just sufficient to cause breaking to commence, and in skeleton beams is simply equal to the tenacity or crushing stress of a separate bar of the material. When the section of the beam is symmetrical above and below, so that the neutral axis lies at the middle of the depth, then the beam will give way according as the tenacity or the resistance to crushing is the less; but in beams of the more ordinary form of cross section (see p. 441) it is generally different from either the direct tenacity or its resistance to crushing, and is generally taken at eighteen times the load that is required to break a bar of an inch square supported at two points one foot apart and loaded in the middle.

### VALUES OF MODULI OF RUPTURE.

|                           |        |
|---------------------------|--------|
| Cast-iron open-work beams | 17,000 |
| „ solid rectangular bars  | 40,000 |
| Wrought-iron plate beams  | 42,000 |
| „ bars and axles          | 54,000 |
| Puddled steel             | 62,500 |
| Steely iron               | 52,500 |

## MOMENT OF RESISTANCE OF BEAMS TO CROSS-BREAKING.

*Note.*—The moment of resistance at a given cross section should be at least equal to the greatest bending moment.

### Skeleton Beam.

$M$  = moment of resistance at given point.

$A$  = sectional area of stringer at given point.

$S$  = greatest safe intensity of stress.

$D$  = perpendicular distance of centre line of stringer from joint.

$$M = ASD.$$

### Beams of Various Sections.

$M$  = moment of resistance at given section.

$I$  = geometrical moment of inertia of section (see p. 441) relatively to neutral axis.

$A$  = area of cross section.

$D$  = depth of beam.

$B$  = breadth of beam.

$d$  = distance of most severely strained layer from neutral axis.

$d'$  = distance of most severely compressed layer from neutral axis.

$s$  = greatest tensile stress on strained layer.

$s'$  = greatest compressive stress on compressed layer.

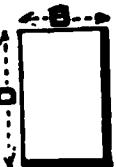
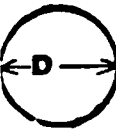



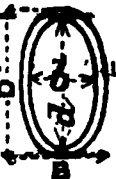


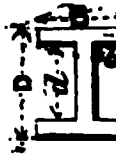

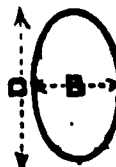

$\frac{d^o}{s^o}$  = lesser of the two quotients  $\frac{d}{s}$  and  $\frac{d'}{s'}$

$k$  and  $c$  = coefficients of form (see annexed table).

$$M = \frac{s^o I}{d^o} = d^o k B D^2 = d^o c D A \quad B = \frac{M}{d^o k D^2} \quad A = \frac{M}{d^o c D}$$

*Note.*—The neutral axis for all practical purposes may be taken at the centre of magnitude of the cross section.

TABLE OF THE VALUES OF COEFFICIENTS OF FORM.

|  |  |  |
|--|--|--|
| <p><i>Solid Rectangle.</i></p>  $I = \frac{B D^3}{12}$ $k = \frac{1}{8}$ $c = \frac{1}{8}$   | <p><i>Solid Circle.</i></p>  $I = \frac{\pi D^4}{64}$ $k = \frac{\pi}{32} = 0.0982$ $c = \frac{1}{8}$                                | <p><i>Thick Hollow Ellipse.</i></p>  $I = \frac{\pi(BD^3 - bd^3)}{64}$ $k = \frac{\pi(BD^3 - bd^3)}{32}$ $c = \frac{BD^3 - bd^3}{8D^2(BD - bd)}$ |
| <p><i>Hollow Rectangle.</i></p>  $I = \frac{BD^3 - bd^3}{12}$ $k = \frac{BD^3 - bd^3}{6BD^3}$ $c = \frac{BD^3 - bd^3}{6D^2(BD - bd)}$ | <p><i>Thick Hollow Circle.</i></p>  $I = \frac{\pi(D^4 - d^4)}{64}$ $k = \frac{\pi(D^4 - d^4)}{32D^4}$ $c = \frac{D^4 - d^4}{8D^4}$ | <p><i>Thin Hollow Ellipse.</i></p>  $I = \frac{\pi(BD^3 - bd^3)}{64}$   |
| <p><i>Thick Hollow Square.</i></p>  $I = \frac{B^4 - b^4}{12}$ $k = \frac{B^4 - b^4}{6B^4}$ $c = \frac{B^4 + b^4}{6b^4}$              | <p><i>Thin Hollow Circle.</i></p>  $I = \frac{\pi(D^4 - d^4)}{64}$ $k = \frac{\pi(D - d)}{8d}$ $c = \frac{1}{4}$                    | <p><i>H Iron.</i></p>  $I = \frac{BD^3 - 2bd^3}{12}$ $k = \frac{BD^3 - 2bd^3}{6BD^3}$ $c = \frac{BD^3 - 2bd^3}{6BD^2(BD - 2bd)}$                |
| <p><i>Thin Hollow Square.</i></p>  $I = \frac{B^4 - b^4}{12}$ $k = \frac{2(B - b)}{3B}$ $c = \frac{1}{3}$                             | <p><i>Solid Ellipse.</i></p>  $I = \frac{\pi B D^3}{64}$ $k = \frac{\pi}{32}$ $c = \frac{1}{8}$                                     | <p><i>Solid Triangle.</i></p>  $I = \frac{B D^3}{36}$ $k = \frac{1}{12}$ $c = \frac{1}{3}$  |

CROSS SECTIONS OF EQUAL STRENGTH. (*Rankine.*)

$s$  = greatest safe tensile stress.

$s'$  = greatest safe compressive stress.

$d$  = distance of strained flange from neutral axis.

$d'$  = distance of compressed flange from neutral axis.

$D = d + d'$ .

$A$  = area of stretched flange.

$A'$  = area of compressed flange.

$A''$  = area of web from centre to centre of flange.

$M$  = moment of resistance.

When  $s$  is greater than  $s'$

$$A' = \frac{sA}{s'} + \frac{s - s'}{2s'} A''$$

$$M = D \left\{ sA + (2s - s') \frac{A''}{6} \right\} = D \left\{ s'A' + (2s' - s) \frac{A''}{6} \right\}$$

When  $s'$  is greater than  $s$

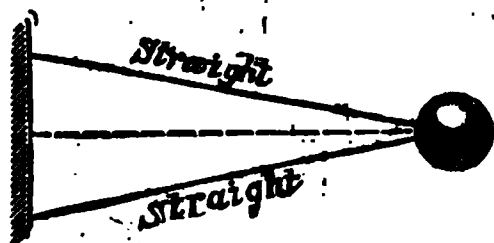
$$A = \frac{s'A'}{s} + \frac{s' - s}{2s} A''$$

$$M = D \left\{ s'A' + (2s' - s) \frac{A''}{6} \right\} = D \left\{ sA + (s' - 2s) \frac{A''}{6} \right\}$$

## TABLE OF BEAMS OF EQUAL STRENGTH THROUGHOUT THEIR LENGTH.

*Note.*—The sections are in all cases supposed to be rectangular.

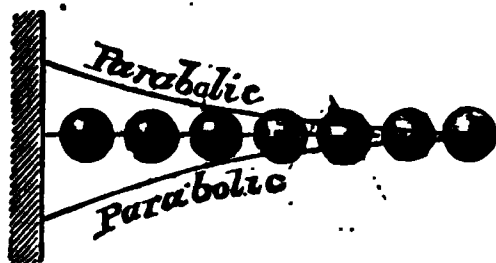
FIG. 163.



*Depth equal throughout.*

Breadth proportional to distance from loaded end.

FIG. 164.



*Depth equal throughout.*

Breadth proportional to square of distance from loaded end.

TABLE OF BEAMS OF EQUAL STRENGTH THROUGHOUT  
THEIR LENGTH (concluded).

FIG. 165.

*Breadth equal throughout.*

Depth proportional to square root of distance from loaded end.

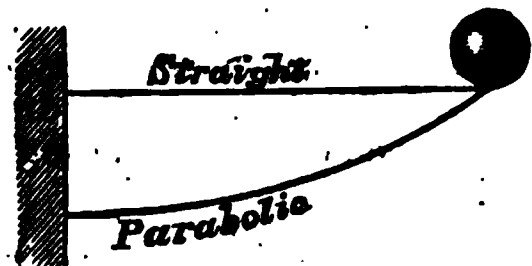


FIG. 166.

*Breadth equal throughout.*

Depth proportional to distance from loaded end.

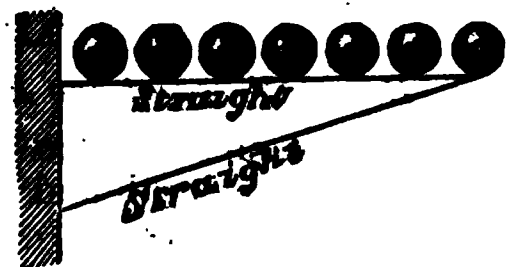


FIG. 167.

*Depth equal throughout.*

Breadth proportional to distance from nearest point of support.

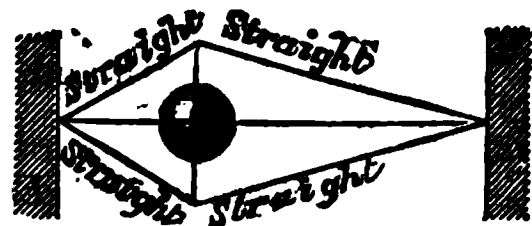


FIG. 168.

*Depth equal throughout.*

Breadth proportional to product of distance from both points of support.

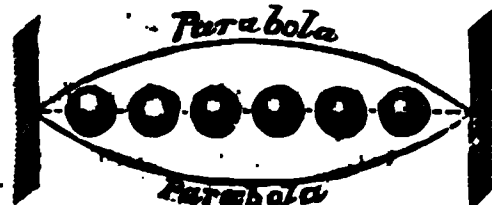


FIG. 169.

*Breadth equal throughout.*

Depth proportional to the square root of the distance from the nearest point of support.

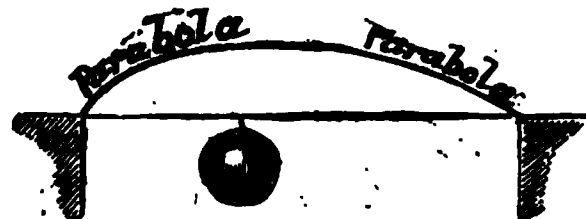
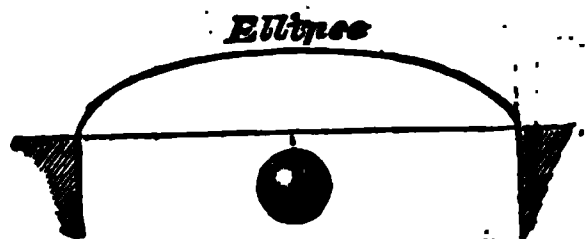


FIG. 170.

*Breadth equal throughout.*

Depth proportional to the product of the square root of the distance from both points of support.



## DEFLECTION OF BEAMS.

$L$  = length or span of beam.

$I$  = moment of inertia of greatest cross section (see pp. 40, 441).

$W$  = load on beam.

$E$  = modulus of elasticity of material (see pp. 269, 270).

$D$  = deflection.  $M$  = bending moment.  $r$  = radius of curvature.

$k$  = coefficient depending on manner of loading and supporting.

$$D = \frac{WL^3k}{EI}$$

$$r = \frac{EI}{M}$$

$$E = \frac{WL^3k}{DI}$$

VALUES OF  $k$ .*Beams Fixed at one End and Loaded at the other.*

|                              |             |
|------------------------------|-------------|
| Uniform cross section        | $k = .3333$ |
| „ strength and uniform depth | $k = .5000$ |
| „ „ „ breadth.               | $k = .6666$ |

*Beams Fixed at one End and Uniformly Loaded.*

|                              |             |
|------------------------------|-------------|
| Uniform cross section        | $k = .1250$ |
| „ strength and uniform depth | $k = .2500$ |
| „ „ „ breadth.               | $k = .5000$ |

*Beams Fixed at both Ends and Loaded at the Centre.*

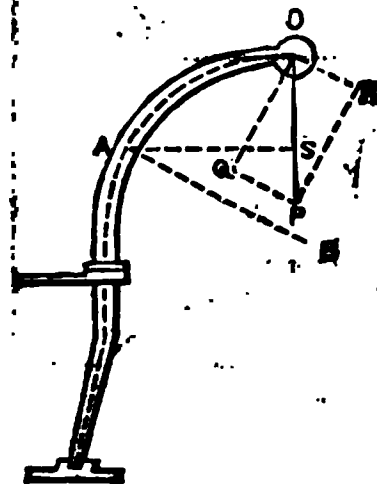
|                              |             |
|------------------------------|-------------|
| Uniform cross section        | $k = .0208$ |
| „ strength and uniform depth | $k = .0313$ |
| „ „ „ breadth.               | $k = .0417$ |

*Beams Fixed at both Ends and Uniformly Loaded.*

|                              |             |
|------------------------------|-------------|
| Uniform cross section        | $k = .0130$ |
| „ strength and uniform depth | $k = .0156$ |
| „ „ „ breadth.               | $k = .0178$ |

FIG. 171.

## STRESS ON DAVITS.



In fig. 171 let  $OP$  represent load,  $A$  the cross section at which it is required to find the stress. Draw  $OQ$  and  $PR$  perpendicular, and  $OR$  and  $QP$  parallel to the plane  $AB$  through the section  $A$ ; let fall  $AS$  perpendicular to  $OP$ .

$M$  = bending moment at  $A$ .

$L$  = direct longitudinal stress.

$a$  = area of section at  $A$ .

$$L = \frac{OQ}{a}$$

$$M = OP \times AS$$

STRENGTH OF SHAFTING TO RESIST TWISTING.

$M$  = moment of resistance in foot pounds.

$D$  = diameter of round shaft or side of square shaft in inches.

$k$  = coefficient depending on material.

*For Round Shafting.*

$$M = .196kD^3$$

$$D = \sqrt[3]{\frac{M}{196k}}$$

*For Square Shafting.*

$$M = .28kD^3$$

$$D = \sqrt[3]{\frac{M}{.28k}}$$

*Values of  $k$  for Working Load.*

|                        |        |                  |       |
|------------------------|--------|------------------|-------|
| Cast iron . . . . .    | 8,100  | Copper . . . . . | 3,800 |
| Wrought iron . . . . . | 9,000  | Brass . . . . .  | 4,100 |
| Cast steel . . . . .   | 17,500 | Tin . . . . .    | 1,200 |
| Gun metal . . . . .    | 4,500  | Lead . . . . .   | 900   |

STRENGTH OF SHAFTING TO RESIST LATERAL STRESS.

$D$  = diameter of round shaft or side of square shaft in inches.

$L$  = length of shaft supported at both ends in feet.

$W$  = weight applied.

$k$  = coefficient depending on form of section and material.

$$D = \sqrt[3]{\frac{LW}{k}} \text{ load applied at middle.}$$

$$D = \sqrt[3]{\frac{LW}{2k}} \text{ load uniformly distributed.}$$

*Values of  $k$ .*

|                           |     |                           |       |
|---------------------------|-----|---------------------------|-------|
| Wood, round . . . . .     | 40  | Wood, square . . . . .    | 70    |
| Cast iron, do. . . . .    | 500 | Cast iron, do. . . . .    | 850   |
| Wrought iron, do. . . . . | 700 | Wrought iron, do. . . . . | 1,200 |

STRENGTH OF RUDDER-HEAD.

$P$  = pressure in tons when rudder is over at 40°.

$A$  = immersed area of rudder in square feet.

$V$  = velocity of water passing rudder in knots per hour.

$T$  = twisting moment on rudder-head in inch tons.

$d$  = distance of centre of rudder area from axis of motion in inches.

## 446 TEST LOADS OF ANCHORS, CHAINS, AND ROPES.

$M$  = moment of resistance of rudder-head to twisting in inch tons.

$k$  = coefficient of 3.5 tons per square inch for iron and .125 ton per square inch for wood.

$$P = \frac{AV^2}{2400}$$

$$T = Pd$$

$$M = .196kD^3$$

$$D = \sqrt[3]{\frac{T}{.196k}}$$

### WEIGHTS AND TEST LOADS OF ANCHORS.

$W$  = weight in cwts. (exclusive of stock).

$T$  = test load in tons.

$L$  = length of anchor in feet.

$A$  = area of augmented surface in square feet.

$w$  = weight of stock in cwts.

$$T = \frac{A}{800}$$

$$W = \frac{L^3}{50}$$

$$w = \frac{W}{5}$$

$$L = \sqrt[3]{50W}$$

### WEIGHT AND TEST LOADS OF CHAINS AND ROPES.

$W$  = weight in tons per hundred fathoms.

$T$  = test load in tons.

$D$  = diameter of chain in inches.

$C$  = circumference of rope in inches.

$$\left. \begin{array}{l} W = .0103C^2 \\ T = .1875C^2 \end{array} \right\} \text{hemp rope hawser-laid.}$$

$$\left. \begin{array}{l} W = .01C^2 \\ T = .15C^2 \end{array} \right\} \text{hemp rope shroud-laid.}$$

$$\left. \begin{array}{l} W = .0096C^2 \\ T = .12C^2 \end{array} \right\} \text{hemp rope cable-laid.}$$

$$\left. \begin{array}{l} W = .039C^2 \\ T = .75C^2 \end{array} \right\} \text{iron-wire rope.}$$

$$\left. \begin{array}{l} W = .04C^2 \\ T = 1.125C^2 \end{array} \right\} \text{iron-steel wire.}$$

$$\left. \begin{array}{l} W = 2.9D^2 \\ T = 12D^2 \end{array} \right\} \text{rigging chain.}$$

$$\left. \begin{array}{l} W = 2.43D^2 \\ T = 18D^2 \end{array} \right\} \text{chain cable.}$$

$$D = \sqrt[3]{\frac{T}{18}}$$

PROPORTIONS OF CHAIN-CABLE LINKS.

|                          |                  |                    |
|--------------------------|------------------|--------------------|
| Length outside           | = 6              | diameters of bolt. |
| " inside                 | = 4              | " "                |
| Breadth outside          | = $3\frac{1}{2}$ | " "                |
| Thickness of stud at end | = 1              | " "                |
| " " middle               | = $\frac{3}{5}$  | " "                |

DESCRIPTION OF CABLES.

*Hemp* is laid up *right-handed* into yarns.  
*Yarns* are laid up *left-handed* into strands.  
*Three strands* laid up *right-handed* make a hawser.  
*Three hawsers* laid up *left-handed* make a cable.  
*Shroud-laid* rope has a *core* surrounded by four strands.

THICKNESS OF IRON SKIN IN SHIPS.

W = displacement in tons.  
 L = length of vessel in feet.  
 B = breadth of vessel in feet.  
 D = depth of vessel in feet.  
 T = thickness of skin.

$$T = \frac{WL}{800BD}$$

RESISTANCE OF IRON SKIN TO BUCKLING.

R = ultimate resistance to buckling in lbs. on the square inch.  
 T = thickness of plating.  
 S = space between frames.

$$R = \frac{400T}{S}$$

RESISTANCE OF WROUGHT-IRON ARMOUR PLATES.

(Fairbairn.)

*Tensile Strain.*

M = coefficient of dynamic resistance in foot lbs..  
 S = breaking strain in lbs. per square inch.  
 L = elongation of material per unit of length.

$$M = \frac{SL}{2}$$

PUNCHING IRON PLATES.

P = pressure in tons to punch a plate.  
 W = work in foot tons to punch a plate.  
 r = radius of punch in inches.  
 t = thickness of plate in inches.

$$P = 114rt$$

$$W = 10640rt^2$$



### PENETRATION OF SHOT INTO IRON ARMOUR.

$d$  = distance of penetration in inches.

$w$  = weight of shot in lbs.

$v$  = velocity of shot in feet per second at time of impact.

$r$  = radius of shot in inches.

$$d = \frac{wv^2}{3374940r} \text{ for round-ended cast-iron service shot.}$$

$$d = \frac{wv^2}{1571360r} \text{ for flat-ended steel shot.}$$

### VELOCITY OF SHOT.

$w$  = weight of shot in lbs.

$w$  = weight of charge in lbs.

$V$  = initial velocity of shot in feet per second.

$v$  = velocity of shot at  $n$  feet per second.

$r$  = radius of shot in inches.

$$v = \frac{2800 \sqrt{w}}{\sqrt{W}}$$

$$v = \frac{V}{1 + \left( 0.0062 \frac{r^2}{W} \right) V n}$$

### IMPACT OF SHOT.

$w$  = weight of shot in lbs.

$v$  = velocity of shot at time of impact.

$I$  = force of impact in lbs.

$$I = \frac{wv^2}{2g} = \frac{wv^2}{64.4} = 0.1553wv^2$$

### TO DETERMINE THE SIZE OF THE RIM OF A FLY-WHEEL.

$v$  = velocity in feet per second at the periphery.

$n$  = number of revolutions per minute.

$d$  = diameter of wheel in feet.

$w$  = weight per foot of rim.

$a$  = sectional area of rim in square inches.

$c$  = centrifugal force for one foot of rim.

$s$  = strain on any section of rim.

$$c = \frac{wv^2}{16.1d}$$

$$s = \frac{cd}{2} = \frac{wv^2}{32.2}$$

$$a = \frac{wv^2}{57900} = \frac{w}{3.2}$$

$$v = \frac{\pi nd}{19}$$

$$n = \frac{2546}{d} \text{ for cast iron.}$$

$$n = \frac{4427}{d} \text{ for wrought iron.}$$

# TO DETERMINE THE SIZE OF THE ARMS OF A FLY-WHEEL TO RESIST CENTRIFUGAL FORCE.

$A$  = area of one arm.

$N$  = number of arms in wheel.

$W$  = weight of wheel.

$a$  = sectional area of rim in square inches.

$d$  = diameter of wheel in feet.

$v$  = velocity in feet per second.

$c$  = centrifugal force on all the arms.

$n$  = number of revolutions per minute.

$$c = \frac{Wv^2}{16 \cdot 1d} = \frac{av^2}{1 \cdot 6} = \frac{a(nd)^2}{577 \cdot 6}$$

$$v = \frac{nd}{19} \quad A = \frac{a(nd)^2}{1039680N}$$

## STRENGTH OF ARMS TO TRANSMIT POWER.

$N$  = number of arms.

$V$  = velocity at outer edge of wheel boss in feet per second.

$L$  = strain at outer edge of wheel boss.

$D$  = diameter of wheel boss in feet.

$H$  = horse power transmitted.

$l$  = length of arms in inches.

$n$  = number of revolutions per minute.

$t$  = thickness of arms in inches.

$w$  = width of arm in inches.

$$L = \frac{33000H}{V} = \frac{10504H}{Dn}$$

$$V = 3 \cdot 1416Dn \quad w = \frac{\sqrt{13Hl}}{DNnt}$$

## STRENGTH OF TEETH OF WHEELS.

$S$  = stress on any tooth.

$H$  = horse power transmitted.

$v$  = velocity of pitch circle in feet per minute.

$t$  = thickness of tooth in inches.

$l$  = length of tooth in inches.

$b$  = breadth of tooth in inches.

$v$  = velocity of pitch circle in feet per second.

$k$  and  $c$  = coefficients.

$$S = \frac{33000H}{V}$$

$$t = k \sqrt{S} = c \sqrt{\frac{H}{v}}$$

$$b = 2l$$

$$k = \begin{cases} \text{for cast iron} & \cdot 025 \\ \text{,, brass} & \cdot 035 \\ \text{,, hard wood} & \cdot 038 \end{cases}$$

$$c = \begin{cases} \text{for cast iron} & \cdot 587 \\ \text{,, brass} & \cdot 821 \\ \text{,, hard wood} & \cdot 891 \end{cases}$$

### PROPORTION OF TEETH OF WHEELS.

|               |               |                |               |
|---------------|---------------|----------------|---------------|
| Depth         | = pitch × .75 | Thickness      | = pitch × .45 |
| Working depth | = „ × .70     | Width of space | = „ × .55     |
| Clearance     | = „ × .05     | Play           | = „ × .10     |

Length beyond pitch line = pitch × .35.

### PITCH AND NUMBER OF TEETH OF WHEELS.

$N$  = number of teeth.

$P$  = pitch of teeth.

$D$  = diameter of wheel in inches.

$\pi = 3.1416$ .

$$N = \frac{\pi D}{P}$$

$$D = \frac{PN}{\pi}$$

$$P = \frac{\pi D}{N}$$

### NUMBER OF TEETH AND REVOLUTIONS OF WHEELS.

$N$  = number of teeth in driving wheel.

$n$  = number of teeth in driven wheel.

$R$  = revolutions of driving wheel.

$r$  = revolutions of driven wheel.

$$N = \frac{nr}{R}$$

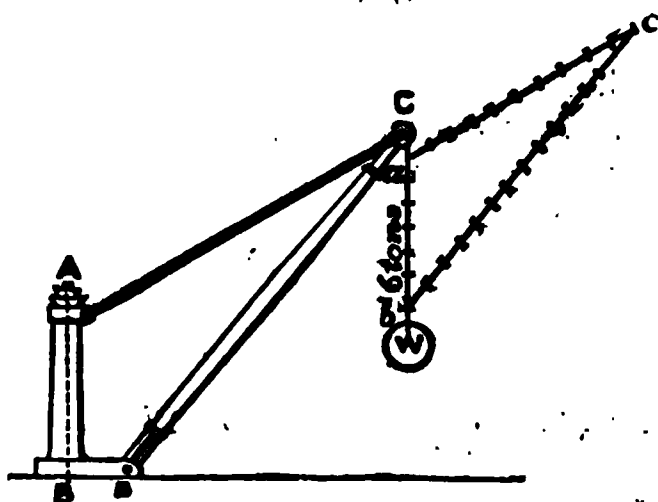
$$n = \frac{NR}{r}$$

$$R = \frac{nr}{N}$$

$$r = \frac{NR}{n}$$

### STRAINS ON CRANES.

FIG. 172.



In fig. 172 let  $ABC$  be a crane,  $AC$  the tie rod,  $BC$  the jib, and  $AB$  the crane post.  $W$  = weight suspended from crane—say, 6 tons. Along the vertical line  $OW$  parallel to  $AB$  draw to any convenient scale  $ab = 6$  tons =  $w$ . From  $b$  draw  $bc$  parallel to  $BC$ , and from  $a$  draw  $ac$  parallel to  $AC$ , cutting  $bc$  in  $c$ . The thrust on the jib  $BC$  will be represented by  $bc$ ,

and is measured by the same scale with which  $ab = 6$  tons was set off. The tension on the tie rod  $AC$  will be represented to the same scale by  $ac$ .

# HAND CRANES.

**P** = power applied to handle in lbs.

**D** = diameter of circle described by handle in inches.

**W** = weight to be lifted in lbs.

**N** = number of revolutions of handle.

**n** = number of revolutions of barrel.

**d** = diameter of barrel in inches.

**l** = length of handle in inches.

$$d = \frac{DPN}{nW} \quad \frac{N}{n} = \frac{Wd}{DP} \quad D = \frac{Wdn}{PN} \quad W = \frac{DPN}{dn}$$

$$P = \frac{Wdn}{DN} \quad l = \frac{Wdn}{PN} \quad n = \frac{PNl}{Wd}$$

*Note.*—The ordinary height of handle above ground is 36 inches. Diameter of circle described by handle, 32 inches. Power imparted by one man, about 15 to 20 lbs.

# STEAM CRANES.

**s** = speed of piston in feet per minute.

**D** = diameter of main drum in feet.

**W** = load to be lifted.

**N** = number of revolutions of main drum per minute.

**P** = pressure on one piston.

**s** = speed of main drum in feet.

**n** = number of revolutions of crank shaft per minute.

**l** = length of stroke in feet.

**d** = diameter of piston in inches.

**p** = pressure of steam in lbs. per square inch.

$$s = 2\pi l \quad s = 3.1416ND \quad P = .7854pd^2$$

$$W = \frac{nlpd^2}{ND}$$

# VELOCITY OF PULLEYS.

**V** = velocity of driving pulley.

**D** = diameter of driving pulley.

**v** = velocity of driven pulley.

**d** = diameter of driven pulley

$$D = \frac{vd}{V} \quad d = \frac{DV}{v} \quad V = \frac{dv}{D} \quad v = \frac{DV}{d}$$

The final velocity of any number of pulleys

$= \frac{V \times D \times D' \times D'' \text{ \&c.},}{d \times d' \times d'' \text{ \&c.},}$  where **D**, **D'**, **D''**, &c., are the diameters of the driving wheel or pulleys, and **d**, **d'**, **d''**, &c., the diameters of the driven pulleys.

PUMPING ENGINES.

G = number of gallons discharged per minute.  
C = number of cubic feet discharged per minute.  
D = diameter of pump in inches.  
L = length of stroke in feet.  
N = number of strokes per minute.  
H = horse power to raise G gallons or C feet per minute.  
h = height water is to be lifted.  
 $G = .03401NLD^2$        $C = .005456NLD^2$

$D = \sqrt{\frac{29.49}{NL}}$  or  $\sqrt{\frac{183.3C}{NL}}$        $H = \frac{Gh}{97020}$  or  $\frac{Ch}{15559}$

HYDRAULIC PRESS.

P = pressure in tons.  
D = diameter of ram in inches.  
L = distance between fulcrum and axis of small pump.  
d = diameter of small pump in inches.  
l = length of pump handle from the fulcrum to point of application of power.  
f = force applied to pump handle in lbs.

$$P = \frac{D^2fl}{2240d^2L}$$

TABLE OF THE PRESSURE OF WATER AT DIFFERENT HEADS.

| H = head in feet.    P = pressure in lbs. per sq. foot.    p = pressure in lbs. per sq. inch. |       |        |    |        |        |    |        |         |
|---|-------|--------|----|--------|--------|----|--------|---------|
| H   | P     | p      | H  | P      | p      | H  | P      | p       |
| 1   | 62.4  | .4333  | 5  | 312.0  | 2.1666 | 30 | 1872.0 | 13.0000 |
| 1.25  | 78.0  | .5416  | 6  | 374.4  | 2.6000 | 40 | 2496.0 | 17.3333 |
| 1.5   | 93.6  | .6500  | 7  | 436.8  | 3.0333 | 50 | 3120.0 | 21.6666 |
| 1.75  | 109.2 | .7853  | 8  | 499.2  | 3.4666 | 60 | 3744.0 | 26.0000 |
| 2   | 124.8 | .8666  | 9  | 571.6  | 3.9000 | 70 | 4368.0 | 30.3333 |
| 3   | 187.2 | 1.3000 | 10 | 624.0  | 4.3333 | 80 | 4992.0 | 34.6666 |
| 4   | 249.6 | 1.7333 | 20 | 1248.0 | 8.6666 | 90 | 5616.0 | 39.0000 |

DISCHARGE OF WATER FROM SLUICES AND ORIFICES.

V = theoretical velocity due to head of water in feet per second.  
H = head of water in feet.  
A = area of aperture or outlet in square feet.  
Q = quantity discharged in cubic feet per second.  
g = force of gravity = 32.2.

$v$  = velocity of real discharge.

$k$  = coefficient for different diameters of sluices.

$$v = \sqrt{2gH} = 8.065 \sqrt{H}$$

$$H = \frac{v^2}{2g} = .01553 v^2$$

$$Q = Ak \sqrt{2gH} = 8.025 Ak \sqrt{H}$$

$$A = \frac{Q}{k \sqrt{2gH}} = \frac{Q}{8.025 k \sqrt{H}}$$

$$v = k \sqrt{2gH} = 8.025 k \sqrt{H}$$

TABLE OF THE VALUES OF COEFFICIENT  $k$ .

| For Short Square Tubes |      |                |     |                |     | For Short Cylindrical Tubes. |     |                |     |                |     |
|------------------------|------|----------------|-----|----------------|-----|------------------------------|-----|----------------|-----|----------------|-----|
| Length<br>Dia.         | $k$  | Length<br>Dia. | $k$ | Length<br>Dia. | $k$ | Length<br>Dia.               | $k$ | Length<br>Dia. | $k$ | Length<br>Dia. | $k$ |
| 0                      | .617 | 20             | .68 | 50             | .59 | 1                            | .62 | 18             | .73 | 49             | .60 |
| 2                      | .814 | 30             | .65 | 60             | .56 | 2                            | .82 | 25             | .68 | 60             | .56 |
| 10                     | .75  | 40             | .62 | 100            | .48 | 4                            | .77 | 37             | .63 | 100            | .48 |

DISCHARGE OF WATER FROM A CISTERN.

$\tau$  = time of discharge in seconds.

$Q$  = rate of discharge (found by above formula).

$W$  = volume of water in cistern in cubic feet.

$$T = \frac{2W}{Q} \text{ for vertical-sided cistern.}$$

$$T = \frac{4W}{3Q} \text{ for wedge-shaped cistern.}$$

$$T = \frac{6W}{5Q} \text{ for pyramidal-shaped cistern.}$$

TIME OF FILLING A CISTERN WHEN SUPPLY AND DISCHARGE ARE GOING ON AT THE SAME TIME.

$P$  = cubic feet of water going in per minute.

$f$  = cubic feet of water going out per minute.

$T$  = time required to fill cistern in minutes.

$t$  = time required to empty cistern in minutes.

$c$  = contents of cistern in cubic feet.

$$T = \frac{c}{P-f}$$

$$t = \frac{c}{f-P}$$

PRESSURE OF WATER ON DOCK GATES.

D = depth of water in feet.  
L = length of one gate in feet.  
T = thrust on ribs in lbs.  
N = normal pressure on the surface of the gates in lbs.  
d = distance from point where gates meet to a righ  
joining their hinges.

$$T = \frac{31 \cdot 2 D^2 L^2}{d}$$

$$N = 32 L D^2$$

FORCE OF WATER IN MOTION.

F = force of water against surface in lbs.  
A = area of surface in square feet,  
V = velocity of water in feet per second.  
V<sub>1</sub> = velocity of water in miles per hour.  
V<sub>2</sub> = velocity of water in knots per hour.  
θ = sine of angle of incidence with opposing surface.

$$F = \theta A V^2 = 2 \cdot 151 \theta A V_1^2 = 2 \cdot 852 \theta A V_2^2.$$

TABLE OF THE FORCE OF WATER IN MOTION.

| Velocity<br>in Feet<br>per Second | Pressure in<br>Lbs. per<br>Square Foot | Velocity<br>in Miles<br>per Hour | Pressure in<br>Lbs. per<br>Square Foot | Velocity<br>in Knots<br>per Hour | Pres<br>Lb<br>Squar |
|-----------------------------------|--|----------------------------------|--|----------------------------------|---------------------|
| 1                                 | 1                                      | 1                                | 2.1511                                 | 1                                | 2                   |
| 2                                 | 4                                      | 2                                | 8.6044                                 | 2                                | 11                  |
| 3                                 | 9                                      | 3                                | 19.3600                                | 3                                | 25                  |
| 4                                 | 16                                     | 4                                | 34.4177                                | 4                                | 45                  |
| 5                                 | 25                                     | 5                                | 53.7777                                | 5                                | 71                  |
| 6                                 | 36                                     | 6                                | 77.4400                                | 6                                | 102                 |
| 7                                 | 49                                     | 7                                | 105.4044                               | 7                                | 139                 |
| 8                                 | 64                                     | 8                                | 137.6711                               | 8                                | 182                 |
| 9                                 | 81                                     | 9                                | 174.2400                               | 9                                | 231                 |
| 10                                | 100                                    | 10                               | 215.1111                               | 10                               | 285                 |
| 11                                | 121                                    | 11                               | 260.2844                               | 11                               | 345                 |
| 12                                | 144                                    | 12                               | 309.7600                               | 12                               | 410                 |
| 13                                | 169                                    | 13                               | 363.5377                               | 13                               | 482                 |
| 14                                | 196                                    | 14                               | 421.6177                               | 14                               | 559                 |
| 15                                | 225                                    | 15                               | 484.0000                               | 15                               | 641                 |
| 16                                | 256                                    | 16                               | 550.6844                               | 16                               | 730                 |
| 17                                | 289                                    | 17                               | 621.6711                               | 17                               | 824                 |
| 18                                | 324                                    | 18                               | 696.9600                               | 18                               | 924                 |
| 19                                | 361                                    | 19                               | 776.5511                               | 19                               | 1029                |
| 20                                | 400                                    | 20                               | 860.4444                               | 20                               | 1140                |

## FLOW OF WATER THROUGH PIPES.

H = head of water in feet.

L = length of pipe in feet.

D = diameter of pipe in feet.

Q = quantity discharged in cubic feet per second.

V = velocity of discharge in cubic feet per second.

k = coefficient of friction = .0258 for rough approximation.

$$H = \frac{kLV^2}{64.4D} = .02 \left( 1 + \frac{1}{12D} \right) \frac{LV^2}{64.4}$$

$$V = 8.025 \sqrt{\frac{HD}{kL}}$$

$$k = .02 \left( 1 + \frac{L}{12D} \right)$$

$$Q = .7854VD^2$$

## TABLE OF COEFFICIENTS OF FRICTION AND ANGLES OF REPOSE.

R = resistance of friction to the sliding of two surfaces.

P = pressure over the surfaces. k = coefficient of friction.

$$R = Pk$$

| Name of Materials         | Coefficient of Friction = $\tan \phi$ | Angle of Repose = $\phi$ |
|---------------------------|---------------------------------------|--------------------------|
| Hemp on dry oak . . .     | .53                                   | 28°                      |
| " wet " . . .             | .33                                   | 18½°                     |
| Iron on stone . . .       | .70 to .30                            | 35½° to 16½°             |
| Metals on metals, dry . . | .15 " .2                              | 8½° " 11½°               |
| " " wet . . .             | .3                                    | 16½°                     |
| Leather " dry . . .       | .56                                   | 29½°                     |
| " " greasy . . .          | .23                                   | 13°                      |
| Leather on oak . . .      | .27 " .38                             | 15° " 19½°               |
| Timber on metals, dry . . | .5 " .6                               | 26½° " 31°               |
| " " soapy . . .           | .2                                    | 11½°                     |
| " stone . . .             | .40                                   | 22°                      |
| " timber, dry . . .       | .25 " .5                              | 14° " 26½°               |
| " " soaped . . .          | .2 " .04                              | 11½° " 2°                |

## SIMPLE AND COMPOUND INTEREST.

P = principal in pounds.

A = amount of principal and interest after n years.

r = rate of interest of £1 for one year.

n = number of years.

Simple  $P = \frac{A}{1 + nr}$

$$A = P(1 + nr)$$

$$r = \frac{A - P}{Pn}$$

Compound  $P = \frac{A}{(1 + r)^n}$

$$A = P(1 + r)^n$$



## ANNUITIES AT SIMPLE AND COMPOUND INTEREST.

P = present value of annuity.      A = annuity to last  $n$  years.

M = amount of principal and interest after  $n$  years.

$r$  = rate of interest of £1 for one year.       $n$  = number of years.

$$\text{Simple} \quad M = An + \frac{n(n-1)Ar}{2} \quad P = \frac{2An + (n-1)r}{2(1+nr)}$$

$$\text{Compound} \quad M = \frac{A}{r} [(1+r)^n - 1] \quad P = \frac{A}{r} \left[ 1 - \frac{1}{(1+r)^n} \right]$$

## ARITHMETICAL PROGRESSION.

L = least or first term.

G = greatest or last term.

S = sum of all the terms.

D = common difference.

$n$  = number of terms.

$$L = G - (n-1)D = \frac{S}{n} - \frac{(n-1)D}{2} = \frac{2S}{n} - G$$

$$G = L + (n-1)D = \frac{2S}{n} - L = \frac{S}{n} + \frac{(n-1)D}{2}$$

$$S = \frac{n}{2} [2L + (n-1)D] = \frac{n}{2} (L + G) = \frac{n}{2} [2G - (n-1)D]$$

$$D = \frac{G-L}{n-1} = \frac{2S-2Ln}{n(n-1)} = \frac{2Gn-2S}{n(n-1)}$$

$$n = 1 + \frac{G-L}{D} = \frac{2S}{L+G} = \frac{2G+D}{2D} = \pm \sqrt{\left[ \left( \frac{2G+D}{2D} \right)^2 - \frac{2S}{D} \right]}$$

## GEOMETRICAL PROGRESSION.

L = least or first term.

G = greatest or last term.

S = sum of all the terms.

R = the common ratio.

$n$  = number of terms.

log = logarithm of any letter.

$$L = \frac{G}{R^{n-1}} = \frac{(R-1)S}{R^n - 1} = RG - (R-1)S$$

$$S = \frac{L(R^n - 1)}{R - 1} = \frac{RG - L}{R - 1} = \frac{G(R-1)}{(R-1)R^{n-1}}$$

$$G = LR^{n-1} = \frac{L + (R-1)S}{R} = \frac{(R-1)SR^{n-1}}{R^{n-1}}$$

$$R = \sqrt[n-1]{\frac{G}{L}} = \frac{S-L}{S-G} = \frac{S}{S-G} R^{n-1} = \frac{G}{S-G}$$

$$n = \frac{\log G - \log L}{\log R} + 1 = \frac{\log G - \log [RG - (R-1)S]}{\log R} + 1$$

CONIC SECTIONS.

ELLIPSE.

If a cone be cut by a plane, as AB in fig. 173, passing through its two slant sides, and not perpendicular to the axis DC, the section will be an ellipse.

In fig. 174  $A$  = major axis.

$a$  = minor axis.

$x$  = abscissa.

$y$  = ordinate.

$$x = \frac{A(a \pm \sqrt{a^2 - y^2})}{2a}$$

$$y = \frac{a\sqrt{A^2 - x^2}}{A}$$

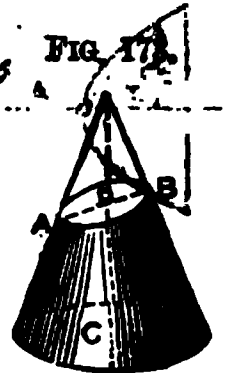


FIG. 174.



FIG. 175.

If a cone be cut by a plane, as AB in fig. 175, parallel to one of its slant sides, the section will be a parabola.

In fig. 176  $A$  = major axis.

$a$  = minor axis.

$x$  = abscissa.

$y$  = ordinate.

$$x = \frac{Ay^2}{a^2}$$

$$y = \frac{a\sqrt{x}}{\sqrt{A}}$$

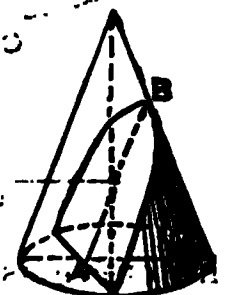
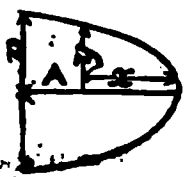


FIG. 176.



HYPERBOLA.

If two cones having the same axis and vertex be cut by a plane, as BD in fig. 177, the section will be a hyperbola, which will consist of two curved branches having their vertices turned towards one another.

In fig. 178  $A$  = major axis.

$a$  = minor axis.

$x$  = abscissa.

$y$  = ordinate.

FIG. 177.

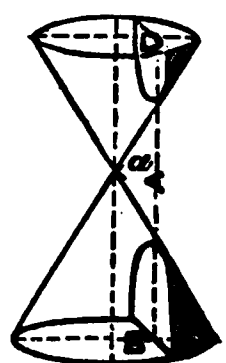
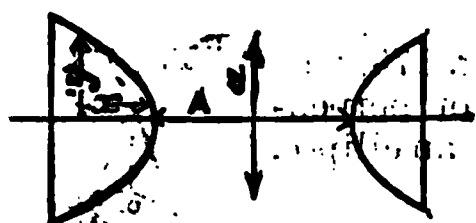


FIG. 178.



$$A = a \omega \frac{\left[ \sqrt{y^2 + \left(\frac{a}{2}\right)^2} + \frac{a}{2} \right]}{y^2}$$

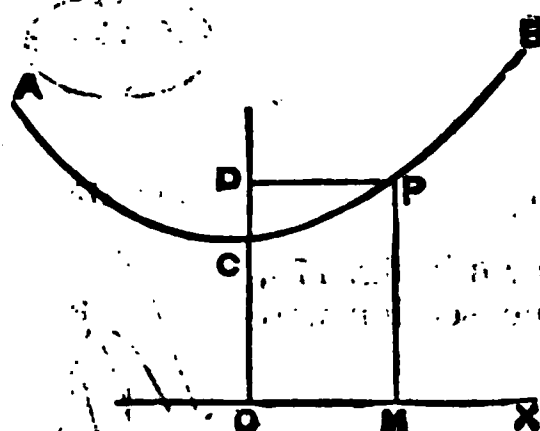
$$a = \frac{\Delta y}{\sqrt{\omega(\Delta + \phi)}}$$

$$\omega = \frac{\Delta(a \pm \sqrt{a^2 + 4y^2})}{2a}$$

$$y = \frac{\omega \sqrt{x(\Delta + x)}}{\Delta}$$

## CATENARY.

FIG. 179.



If a uniform chain be freely suspended from two points, A and B, the curve in which it will hang is termed a common catenary; the parameter OC is equal to the length of a piece of the chain whose weight is equal to the tension at the lowest point C in the curve.

The directrix OX is a horizontal line drawn through the extremity O of the parameter.

The tension at any point P in the curve is equal to the length of a piece of the chain whose weight is equal to the tension at the point, and is thus equal to the ordinate PM.

*Equations to the Catenary* (see fig. 179).

$x$  = abscissa.

$y$  = ordinate.

$c$  = tension at c.

$s$  = length CP of chain.

*Cartesian.*

$$y = \sqrt{c^2 + s^2} = \frac{c}{2} \left( e^{\frac{x}{c}} + e^{-\frac{x}{c}} \right)$$

$$s^2 = y^2 - c^2 = \frac{c}{2} \left( e^{\frac{x}{c}} - e^{-\frac{x}{c}} \right)$$

*Approximate Equation.*

$$x^2 = 2c(y - c) - \frac{1}{3}(y - c)^3$$

*Formulae for the Catenary when the points of support are in the same horizontal plane (see fig. 180).*

$s$  = span.

$h$  = height or dip.

$p$  = parameter.

$l$  = length of chain.

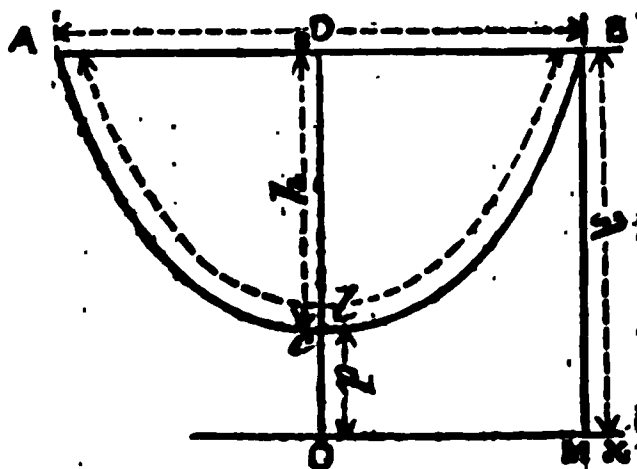
$w$  = weight of unit of chain.

$t$  = tension at A or B.

$c$  = tension at  $c$ .

$y$  = ordinate at A or B.

FIG. 180.



$$p = \frac{c}{w}$$

$$y = \frac{t}{w} = p + h = p + \frac{s^2}{8p} + \frac{s^4}{384p^3}$$

$$+ \frac{s^6}{46080p^5} + \&c.$$

$$t = yw$$

$$c = pw$$

$$l = s + \frac{s^3}{24p^2} + \frac{s^5}{1920p^4} + \&c.$$

$$h = \frac{s^2}{8p} + \frac{s^4}{384p^3} + \frac{s^6}{46080p^5} + \&c.$$

*Approximate Formulae.*

$$p = \frac{1}{4} \left[ 4y + \sqrt{(3y)^2 - 21\left(\frac{s}{2}\right)^2} \right] = \frac{s^2}{8h} + \frac{h}{6} \text{ nearly.}$$

$$h = \frac{1}{4} \left[ 3y - \sqrt{(3y)^2 - 21\left(\frac{s}{2}\right)^2} \right] = \frac{s^2}{8y} \text{ nearly.}$$

$$l = \sqrt{\left(s^2 + \frac{16}{3}h^2\right)} = s + \frac{8h^2}{3s} \text{ nearly.}$$

$$y = \frac{s^2}{8h} + \frac{7h}{6} = \frac{s^2}{8l} \text{ nearly.}$$

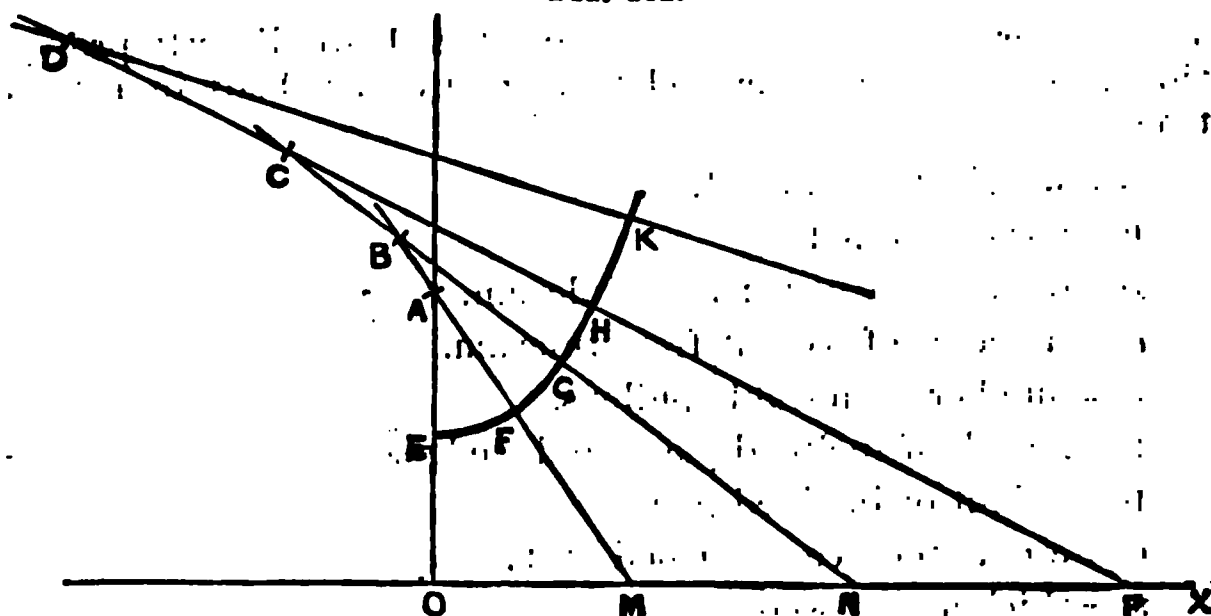
Catenaries that make equal angles at the points of suspension with their ordinates or horizontal dimensions are similar figures.

TABLE OF RELATIONS OF CATENARIAN CURVES, THE  
PARAMETER BEING TAKEN AS UNITY.

| Angle of<br>Suspension | $A$    | $\frac{B}{2}$ | $\frac{I}{2}$ | $y$    | $\frac{G}{2} + h$ |
|------------------------|--------|---------------|---------------|--------|-------------------|
| 1° 0'                  | ·00015 | ·01745        | ·01745        | 1·0001 | 114·566           |
| 2° 0'                  | ·00061 | ·08491        | ·08492        | 1·0006 | 57·379            |
| 3° 0'                  | ·00137 | ·05238        | ·05241        | 1·0014 | 38·171            |
| 4° 0'                  | ·00244 | ·06987        | ·06992        | 1·0024 | 28·618            |
| 5° 0'                  | ·00382 | ·08738        | ·08749        | 1·0038 | 22·874            |
| 6° 0'                  | ·00551 | ·10491        | ·10510        | 1·0055 | 19·046            |
| 7° 0'                  | ·00751 | ·12248        | ·12278        | 1·0075 | 16·809            |
| 8° 0'                  | ·00983 | ·14008        | ·14054        | 1·0098 | 14·254            |
| 9° 0'                  | ·01247 | ·15773        | ·15838        | 1·0125 | 12·654            |
| 10° 0'                 | ·01543 | ·17542        | ·17688        | 1·0154 | 11·372            |
| 11° 0'                 | ·01872 | ·19318        | ·19438        | 1·0187 | 10·820            |
| 12° 0'                 | ·02234 | ·21099        | ·21256        | 1·0223 | 9·444             |
| 13° 0'                 | ·02630 | ·22887        | ·23087        | 1·0263 | 8·701             |
| 14° 0'                 | ·03061 | ·24681        | ·24933        | 1·0306 | 8·062             |
| 15° 0'                 | ·03528 | ·26484        | ·26795        | 1·0353 | 7·508             |
| 16° 0'                 | ·04030 | ·28296        | ·28675        | 1·0403 | 7·021             |
| 17° 0'                 | ·04569 | ·30116        | ·30573        | 1·0457 | 6·591             |
| 18° 0'                 | ·05146 | ·31946        | ·32492        | 1·0515 | 6·208             |
| 19° 0'                 | ·05762 | ·33786        | ·34438        | 1·0576 | 5·863             |
| 20° 0'                 | ·06418 | ·35637        | ·36387        | 1·0642 | 5·553             |
| 21° 0'                 | ·07114 | ·37502        | ·38386        | 1·0711 | 5·271             |
| 22° 0'                 | ·07853 | ·39376        | ·40403        | 1·0786 | 5·014             |
| 23° 0'                 | ·08636 | ·41267        | ·42447        | 1·0864 | 4·778             |
| 24° 0'                 | ·09464 | ·43169        | ·44523        | 1·0946 | 4·562             |
| 25° 0'                 | ·10338 | ·45087        | ·46631        | 1·1034 | 4·361             |
| 26° 0'                 | ·11260 | ·47021        | ·48773        | 1·1126 | 4·176             |
| 28° 0'                 | ·13267 | ·50940        | ·53171        | 1·1326 | 3·843             |
| 30° 0'                 | ·15470 | ·54989        | ·57785        | 1·1547 | 3·551             |
| 32° 0'                 | ·18004 | ·5912         | ·62649        | 1·1800 | 3·284             |
| 34° 0'                 | ·21003 | ·6371         | ·68130        | 1·2100 | 3·034             |
| 36° 0'                 | ·24995 | ·6932         | ·74991        | 1·2499 | 2·773             |
| 39° 0'                 | ·29011 | ·7443         | ·81510        | 1·2901 | 2·567             |
| 41° 0'                 | ·34004 | ·8029         | ·89201        | 1·3400 | 2·362             |
| 44° 0'                 | ·39016 | ·8566         | ·96569        | 1·3902 | 2·196             |
| 46° 0'                 | ·43999 | ·9066         | 1·0361        | 1·4400 | 2·060             |
| 48° 0'                 | ·49981 | ·9623         | 1·1173        | 1·4998 | 1·925             |
| 50° 0'                 | ·56005 | 1·0142        | 1·1974        | 1·5600 | 1·811             |
| 52° 0'                 | ·62973 | 1·0706        | 1·2869        | 1·6297 | 1·699             |
| 54° 0'                 | ·71021 | 1·1304        | 1·3874        | 1·7102 | 1·592             |
| 56° 0'                 | ·81021 | 1·1995        | 1·5089        | 1·8102 | 1·481             |
| 58° 0'                 | ·88972 | 1·2510        | 1·6034        | 1·8897 | 1·416             |
| 60° 0'                 | 1·0000 | 1·3169        | 1·7871        | 2·0000 | 1·377             |
| 64° 0'                 | 1·2394 | 1·4202        | 2·0594        | 2·2394 | 1·140             |
| 67° 0'                 | 1·6095 | 1·6185        | 2·4102        | 2·6095 | 1·002             |
| 67° 32'                | 1·6168 | 1·6164        | 2·4182        | 2·6168 | 0·9998            |

TO CONSTRUCT A CATENARY GEOMETRICALLY.

Fig. 181.



Let E be the lowest point in the curve, OE its parameter, and OX its directrix. Make AE equal to OE; then with A as centre and AE as radius describe the small arc EF. Join FA and produce it to M and to B, making BF equal to FM; then with B as centre and BF as radius describe the small arc FG. Join BG and produce it to N and to C, making CG equal to GN; then with C as centre and CG as radius describe the small arc GH. Proceed in a similar manner till the curve is of the required length.

WEIGHTED ROPE.

To determine the position a weight will take when hung on a rope suspended from two points not in the same horizontal plane.

Let A and B be the two points of suspension; make BC equal to the length of the rope; bisect AC in D: the point E where the perpendicular DE cuts BC will be the point at which the weight will hang.

$l$  = length of rope.

$d$  = distance between points of suspension.

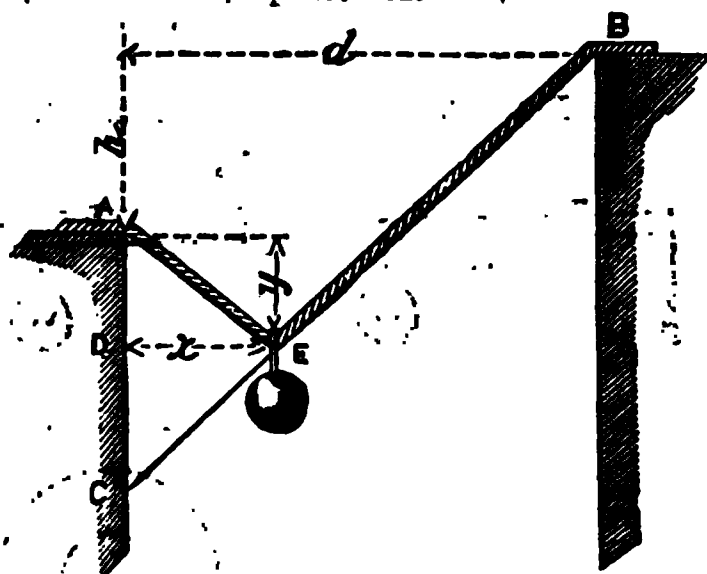
$h$  = height of one support above the other.

$x$  and  $y$  = co-ordinates of the point.

$$y = \sqrt{\frac{(l^2 - d^2)}{2}} - h$$

$$x = \frac{yd}{\sqrt{(l^2 - d^2)}}$$

FIG. 182.



## MECHANICAL POWERS.

THE power applied and the weight lifted are directly proportional to the distances moved through by each body in a given time.

$W$  = weight to be raised.

$P$  = power applied.

$D$  = distance of power from fulcrum.

$d$  = distance of weight from fulcrum.

$n$  = number of movable pulleys.

$L$  = length of inclined plane and wedge.

$H$  = height of inclined plane.

$C$  = circumference described by  $P$ .

$t$  = thickness of wedge.

$s$  = distance moved through by  $P$ .

$s$  = distance moved through by  $W$ .

$R$  = resistance to wedge.

$p$  = pitch of screw.

## GENERAL FORMULÆ FOR ALL THE POWERS.

$$W = \frac{SP}{s} \quad P = \frac{Ws}{S} \quad S = \frac{Ws}{P} \quad s = \frac{SP}{W}$$

## THE LEVER AND WHEEL AND AXLE.

$$W = \frac{PD}{d} \quad P = \frac{Wd}{D} \quad D = \frac{Wd}{P} \quad d = \frac{PD}{W}$$

FIG. 183.

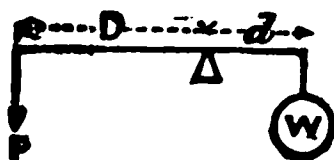


FIG. 184.

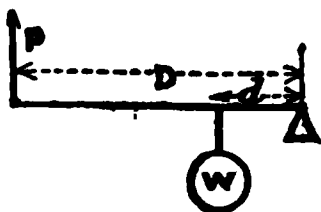


FIG. 185.

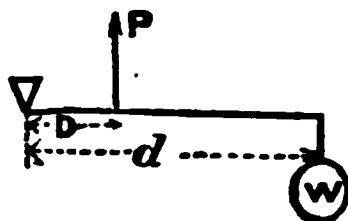
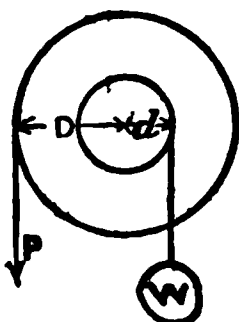


FIG. 186.



THE PULLEY.

$$W = 2Pn \quad P = \frac{W}{2n}$$

FIG. 187.

ONE MOVABLE PULLEY.

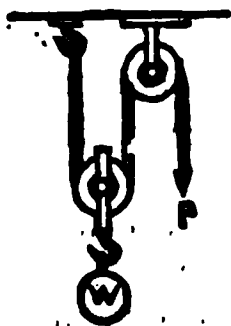


FIG. 188.

TWO MOVABLE PULLEYS.



*Note.*—For revolutions of wheels see p. 451.

THE INCLINED PLANE.

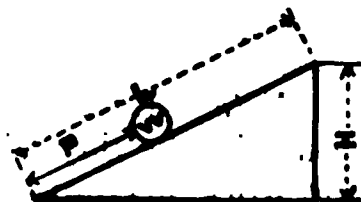
$$W = \frac{PL}{H}$$

$$P = \frac{WH}{L}$$

$$H = \frac{PL}{W}$$

$$L = \frac{WH}{P}$$

FIG. 189.



THE WEDGE.

$$R = \frac{PL}{t}$$

$$P = \frac{Rt}{L}$$

$$t = \frac{PL}{R}$$

FIG. 190.



THE SCREW.

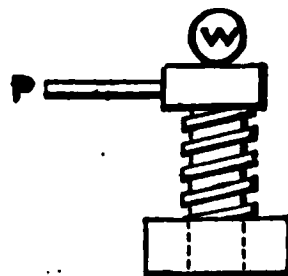
$$W = \frac{PC}{p}$$

$$P = \frac{Wp}{C}$$

$$p = \frac{PC}{W}$$

$$C = \frac{Wp}{P}$$

FIG. 191.



*Note.*—One-third more power than is obtained by the foregoing formulæ is generally allowed, in order to overcome the resistance due to friction, &c., weight and power being in equilibrium.



## FORCE, POWER, AND WORK. (John W. Nystrom.)

$S$  = space in feet passed through by the force  $F$  in the time  $T$ .

$F$  = force or pressure in lbs.

$V$  = velocity in feet per second.

$T$  = time of operation in seconds.

$P$  = power in foot lbs. of one pound raised one foot per second.

$H$  = horse power of 550 lbs. raised one foot per second.

$W$  = physical work expressed in workman days of 1,980,000 foot lbs.

$M$  = weight in lbs. of moving mass, or the weight of a mass acted upon by a mechanical force.

$G$  = acceleration of the combined gravity and mechanical force.

$g$  = accelerating force of gravity = 32.166 feet per second.

$L$  = number of labourers employed (not workman days).

$D$  = number of days of eleven working hours.

$N$  = number of horses (not horse power).

$n$  = number of blows of steam hammer or pile-driver.

*Note.*—By a workman day is meant a man's day's work of 11 hours in the day when the work done is supposed to be equal to the work accomplished by one horse-power in the time of one hour.

## FORMULÆ FOR MECHANICAL WORK.

$$S = VT = \frac{PT}{F} = \frac{550TH}{F} = \frac{550 \times 3600W}{F}$$

$$F = \frac{P}{V} = \frac{550HT}{S} = \frac{550 \times 3600W}{VT} = \frac{550 \times 3600W}{S}$$

$$V = \frac{S}{T} = \frac{P}{F} = \frac{550H}{F} = \frac{550 \times 3600W}{FT}$$

$$T = \frac{S}{V} = \frac{SF}{P} = \frac{SF}{550H} = \frac{550 \times 3600W}{FV}$$

$$P = FV = \frac{FS}{T} = 550H = \frac{550 \times 3600W}{T}$$

$$H = \frac{P}{550} = \frac{FV}{550} = \frac{FS}{550T} = \frac{3600W}{T}$$

$$W = \frac{FVT}{550 \times 3600} = \frac{FS}{550 \times 3600} = \frac{PT}{550 \times 3600} = \frac{HT}{3600}$$

$$N = \frac{L}{11} = \frac{W}{11D} = \frac{FV}{550} = \frac{FS}{11 \times 550 \times 3600D}$$

$$D = \frac{W}{L} = \frac{W}{11N} = \frac{50W}{FV} = \frac{FS}{550 \times 3600L}$$

$$W = DL = HDN = \frac{FVD}{50} = \frac{F^2VS}{50 \times 550 \times 3600L}$$

FORMULÆ FOR WORK UNDER THE ACTION OF GRAVITY.

$$S = \frac{gT^2}{2} = \frac{VT}{2} = \frac{PT}{2M} = \frac{4 \times 550^2 H^2}{2gM^2} = \frac{550 \times 3600W}{M}$$

$$M = \frac{2 \times 550 \times 3600W}{gT} = \frac{550 \times 3600W}{S} = \frac{2 \times 550H}{\sqrt{2gs}} = \frac{550 \times 3600Wg}{V^2}$$

$$V = gT = \frac{2S}{T} = \frac{2 \times 550H}{M} = \sqrt{2gs} = \sqrt{\frac{550 \times 3600gW}{M}}$$

$$T = \frac{2 \times 550H}{gM} = \sqrt{\frac{2S}{g}} = \sqrt{\frac{550 \times 3600 \times 2W}{gM}}$$

$$P = \frac{MTg}{2} = \frac{MV}{2} = \frac{M2S}{T} = 550 \times 3600W \sqrt{\frac{g}{2S}}$$

$$H = \frac{MTg}{2 \times 550} = \frac{M\sqrt{2gs}}{2 \times 250} = \frac{MV}{2 \times 250} = \frac{3600W}{T}$$

$$W = \frac{MV^2}{2 \times 550g \times 3600} = \frac{MS}{550 \times 3600} = \frac{P\sqrt{\frac{2S}{g}}}{550 \times 3600} = \frac{H\sqrt{\frac{2S}{g}}}{3600}$$

$$L = \frac{MSn}{550 \times 3600D}$$

$$D = \frac{MSn}{550 \times 3600L}$$

$$N = \frac{MSn}{11 \times 550 \times 3600D}$$

$$W = \frac{MSn}{550 \times 3600}$$

*Note.*—One horse-power = 550 foot lbs. per second = 33,000 foot lbs. per minute = 1,980,000 foot lbs. per hour.

TABLE OF WORK DONE BY MEN AND ANIMALS. (*From  
Townsend's 'Practical Mechanics.'*)

| NATURE OF LABOUR  | Daily Duration<br>of Work<br>in Hours | No. of Units<br>of Work<br>per Day | No. of Units<br>of Work<br>per Minute | Weight Raised,<br>or Mean<br>Pressure, in Lbs. | Velocity<br>in Feet<br>per Minute |
|---|---------------------------------------|------------------------------------|---------------------------------------|--|-----------------------------------|
| <b>1. Raising Weights Vertically.</b>   |                                       |                                    |                                       |  |                                   |
| A man mounting a gentle incline or ladder without burden—i.e. raising his own weight              | 8-0                                   | 208,200                            | 4,380                                 | 145  | 29                                |
| Labourer raising weights with rope and pulley, the rope returning without load                    | 6-0                                   | 568,000                            | 1,560                                 | 40   | 89                                |
| Labourer lifting weights by hand  | 6-0                                   | 581,000                            | 1,480                                 | 44   | 84                                |
| Labourer carrying weights on his back up a gentle incline or up a ladder, and returning unladen   | 6-0                                   | 406,000                            | 1,180                                 | 145  | 8                                 |
| Labourer wheeling materials in a barrow up an incline of 1 in 12, and returning with empty barrow | 10-0                                  | 818,000                            | 520                                   | 180  | 4                                 |
| Labourer lifting earth with a spade to a mean height of 5½ feet                                   | 10-0                                  | 281,000                            | 470                                   | 6  | 78                                |
| <b>2. Action on Machines.</b>   |                                       |                                    |                                       |  |                                   |
| Labourer walking and pushing or pulling horizontally  | 8-0                                   | 150,000                            | 3,180                                 | 27   | 116                               |
| Labourer turning a winch.   | 8-0                                   | 1,250,000                          | 2,600                                 | 18   | 144                               |
| Labourer pushing and pulling alternately in a vertical direction                                  | 8-0                                   | 1,146,000                          | 2,890                                 | 11   | 216                               |
| Horse yoked to a cart and walking   | 10-0                                  | 15,888,000                         | 26,150                                | 150  | 175                               |
| Horse yoked to a whim gin   | 8-0                                   | 8,440,000                          | 17,600                                | 100  | 175                               |
| Do. do., trotting   | 4-5                                   | 7,036,000                          | 26,060                                | 66½  | 391                               |

One man can lift with both hands 236 lbs.

" " " support on his shoulders 330 lbs.

A man's strength is greatest in raising a weight when his weight is to that of his load as 4 is to 8.

*Note.*—In the above table the unit of work is taken at a pressure of 1 lb. exerted through 1 foot.

TABLE GIVING THE USEFUL EFFECT OF AGENTS EMPLOYED IN THE HORIZONTAL TRANSPORT OF BURDENS. (*From Twisden's 'Practical Mechanics.'*)

| AGENT   | Duration of Daily Work | Useful Effect Daily | Useful Effect per Minute | Weight Transported in Lbs. | Velocity in Feet per Minute |
|---|------------------------|---------------------|--------------------------|----------------------------|-----------------------------|
| Man walking on a horizontal road without burden—that is, transporting his own weight            | 10·0                   | 25,398,000          | 42,330                   | 145                        | 292                         |
| Labourer transporting material in a truck on two wheels, returning with it empty for a new load | 10·0                   | 13,025,000          | 21,710                   | 220                        | 99                          |
| Do. do., with a wheel-barrow  | 10·0                   | 7,815,000           | 13,030                   | 180                        | 160                         |
| Labourer walking with a weight on his back  | 7·0                    | 5,470,000           | 13,030                   | 90                         | 145                         |
| Labourer transporting materials on his back, and returning unburdened for a new load            | 6·0                    | 5,087,000           | 14,100                   | 145                        | 97                          |
| Do. do., on a hand-barrow.  | 10·0                   | 4,298,000           | 7,160                    | 110                        | 65                          |
| Horse transporting material in a cart, walking, always laden                                    | 10·0                   | 200,582,000         | 334,300                  | 1,500                      | 223                         |
| Do. do., trotting   | 4·5                    | 90,262,000          | 334,300                  | 750                        | 44                          |
| Do. do., transporting materials in a cart, returning with the cart empty for a new load         | 10·0                   | 10,940,800          | 182,350                  | 1,500                      | 121                         |
| Horse walking with a weight on his back   | 10·0                   | 34,385,000          | 57,310                   | 270                        | 212                         |
| Do. do., trotting   | 7·0                    | 32,072,000          | 76,410                   | 180                        | 424                         |

*Note.*—The useful effect in the above table is the product of the weight in lbs. and the distance in feet.

**BOARD OF TRADE REGULATIONS FOR MARINE BOILERS, ETC.**

**BOILERS AND SUPERHEATERS.**

*Pressures on Flat Surfaces.*

ON flat surfaces the pressure should not exceed 5,000 lbs. to each effective square inch of sectional area of stay; but if in any case a greater pressure is required, where the flat surfaces are stiffened by T or L irons, the mode of stiffening must be submitted to the Board of Trade for approval.

*To find the area of any diagonal stay.*

**RULE.**—Find the area of a direct stay needed to support the surface; multiply this area by the length of the diagonal stay, and divide the product by the length of a line drawn at right angles to the surface supported at the end of the diagonal stay.

**Note.**—When gusset stays are used their area should be in excess of that found by the above rule.

### *Girders for Flat Surfaces.*

When the tops of combustion boxes, or other parts of a boiler, are supported by solid rectangular girders, the following formula may be used for finding the working pressure to be allowed on the girders, assuming that they are not subjected to a greater temperature than the ordinary heat of steam, and in the case of combustion chambers that the ends are fitted to the edges of the tube plate and the back plate of the combustion box:—

#### FORMULA.

P = working pressure.

L = length of girder in feet.

D = depth of girder in inches.

T = thickness of girder in inches.

W = width of combustion box in inches.

p = pitch of supporting bolts in inches.

d = distance between the girders from centre to centre in inches.

k = 500 when the girder is fitted with one supporting bolt,  
= 750 when fitted with two or three supporting bolts,  
= 850 when fitted with four supporting bolts.

$$P = \frac{k \times D^2 \times T}{(W - p)d \times L}$$

### *Plates for Flat Surfaces.*

The pressure on plates forming flat surfaces may be found by the following formula:—

#### FORMULA.

W = working pressure.

T = thickness of plate in sixteenths of an inch.

S = surface supported in square inches.

k = constant according to the following circumstances:—

$k = 100$  when the plates are not exposed to the impact of heat or flame and the stays are fitted with nuts and washers, the latter being at least three times the diameter of the stay and two-thirds the thickness of the plate they cover.

$k = 90$  when the plates are not exposed to the impact of heat or flame and the stays are fitted with nuts only.

$k = 60$  when the plates are exposed to the impact of heat or flame and steam in contact with the plates, and the stays fitted with nuts and washers, the latter being at least three times the diameter of the stay and two-thirds the thickness of the plates they cover.

$k = 54$  when the plates are exposed to the impact of heat or flame and steam in contact with the plate, and the stays fitted with nuts only.

$k = 80$  when the plates are exposed to the impact of heat or flame with water in contact with the plates, and the stays screwed into the plate and fitted with nuts.

$k = 60$  when the plates are exposed to the impact of heat or flame, with water in contact with the plate, and the stays screwed into the plate having the ends riveted over to form a substantial head.

$k = 36$  when the plates are exposed to the impact of heat or flame and steam in contact with the plates, with the stays screwed into the plate and having the ends riveted over to form a substantial head.

$$W = \frac{k \times (T + 1)^2}{s - 6}$$

### *Cylindrical Boilers.*

When cylindrical boilers are made of the best material, with all the rivet holes drilled in place and all the seams fitted with double butt-straps, each of at least  $\frac{5}{8}$  the thickness of the plates they cover, and all the seams at least double-riveted with rivets having an allowance of not more than 50 per cent. over the single shear, and provided that the boilers have been open to inspection during the whole period of construction, then 6 may be used as the factor of safety; but the boilers must be tested by hydraulic pressure to twice the working pressure. But when the above conditions are not complied with the additions in the following table must be added to the factor 6, according to the circumstances of the case.

TABLE GIVING THE CONSTANTS TO BE ADDED TO THE  
FACTOR OF SAFETY FOR CYLINDRICAL BOILERS.

| Mark | Con-<br>stants | Circumstances in which the Constants have to be added   |
|------|----------------|---|
| A    | ·15            | When the holes are fair and good in the longitudinal seams, but drilled out of place after bending.             |
| B    | ·3             | When the holes are fair and good in the longitudinal seams, but drilled out of place before bending.            |
| C    | ·3             | When the holes are fair and good in the longitudinal seams, but punched after bending instead of drilled.       |
| D    | ·5             | When the holes are fair and good in the longitudinal seams, but punched before bending.                         |
| E*   | ·5             | When the holes are not fair and good in the longitudinal seams.   |
| F    | ·1             | When the holes are fair and good in the circumferential seams, but drilled out of place after bending.          |
| G    | ·15            | When the holes are fair and good in the circumferential seams, but drilled before bending.                      |
| H    | ·15            | When the holes are fair and good in the circumferential seams, but punched after bending.                       |
| I    | ·2             | When the holes are fair and good in the circumferential seams, but punched before bending.                      |
| J*   | ·2             | When the holes are not fair and good in the circumferential seams.  |
| K    | ·2             | When double butt-straps are not fitted to the longitudinal seams, and said seams are lap and double-riveted.    |
| L    | ·1             | When double butt-straps are not fitted to the longitudinal seams and the said seams are lap and treble-riveted. |
| M    | ·3             | When only single butt-straps are fitted to the longitudinal seams and the said seams are double-riveted.        |
| N    | ·15            | When only single butt-straps are fitted to the longitudinal seams and the said seams are treble-riveted.        |
| O    | ·1             | When any description of joint in the longitudinal seams is single-riveted.                                      |
| P    | ·1             | When the circumferential seams are fitted with single butt-straps and are double-riveted.                       |

\* The allowance may be increased still further if the workmanship or material is very doubtful or very unsatisfactory.

TABLE GIVING THE CONSTANTS TO BE ADDED TO THE FACTOR OF SAFETY FOR CYLINDRICAL BOILERS (concluded).

| Mark | Con-<br>stants | Circumstances in which the Constants have to be added  |
|------|----------------|--|
| Q    | ·2             | When the circumferential seams are fitted with single butt-straps and are single-riveted.  |
| R    | ·1             | When the circumferential seams are fitted with double butt-straps and are single-riveted.  |
| S    | ·1             | When the circumferential seams are lap joints and are double-riveted.  |
| T    | ·2             | When the circumferential seams are lap joints and are single-riveted.  |
| U    | ·25            | When the circumferential seams are lap and the strakes or plates are not entirely under or over.   |
| V    | ·3             | When the boiler is of such a length as to fire from both ends, or is of unusual length, such as flue boilers, and the circumferential seams are fitted as described opposite P, R, and S; but when the circumferential seams are as described opposite Q and T, V ·3 will become V ·4. |
| W*   | ·4             | When the seams are not properly crossed.   |
| X*   | ·4             | When the iron is in any way doubtful and the surveyor is not satisfied that it is of the best quality.   |
| Y    | 1·65           | When the boiler is not open to inspection during the whole period of its construction.   |

*Strength of Joints in Cylindrical Boilers.*

## FORMULA.

P = percentage of strength of plate at joint as compared with the solid plate.

P' = percentage of strength of rivets as compared with the solid plate.†

$p$  = pitch of rivets.

$d$  = diameter of rivets.

$a$  = area of rivets.

$n$  = number of rows of rivets.

$t$  = thickness of plate.

$$P = \frac{(p - d) \times 100}{p}$$

$$P' = \frac{(a \times n) \times 100}{p \times t}$$

Then take iron as equal to 23 tons, and use the smallest of the two percentages as the strength of the joint, and adopt the factor of safety as found from the preceding table.

\* The allowance may be increased still further if the workmanship or material is very doubtful or very unsatisfactory.

† If the rivets are exposed to double shear, multiply the percentage as found by 1·5.



*Pressure on Safety Valves in Cylindrical Boilers.*

## FORMULA.

$P$  = pressure to be allowed per square inch.

$s$  = percentage of strength of joint.

$D$  = inside diameter of boiler in inches.

$t$  = thickness of plate.

$f$  = factor of safety.

$$P = \frac{(51520 \times s) \times 2t}{D \times f}$$

*Plates, Butt Straps, Size of Rivets, &c., of Cylindrical Boilers.*

Plates that are drilled in place *must* be taken apart and the burr taken off; and the holes slightly countersunk from the outside.

Butt straps *must* be cut from plates and *not* from bars, and must be of as good quality as the shell plates, and those for the longitudinal seams *must* be cut across the fibre. The rivet holes may be punched or drilled out of place, but when drilled in place must be taken apart and the burr taken off and slightly countersunk from the outside.

When single butt-straps are used, and the rivet holes in them punched, they *must* be one-eighth thicker than the plates they cover. The diameter of the rivets *must* not be less than the thickness of the plates of which the shell is made, but it will be found when the plates are thin, or when lap joints or single butt-straps are adopted, that the diameter of the rivets should be in excess of the thickness of the plates.

Dished ends that are not truly hemispherical must be stayed; if they are not theoretically equal in strength to the pressure needed they must be stayed as flat surfaces, but if they are theoretically equal in strength to the pressure needed the stays may have a strain of 10,000 lbs. per effective square inch of sectional area.

The strength of a sphere to resist internal pressure may be taken as double that of a cylinder of the same diameter and thickness.

All manholes and openings must be stiffened with compensating rings of at least the same effective sectional area as the plates cut out, and in no case should the plate rings be less in thickness than the plates to which they are attached. The openings in the shells of cylindrical boilers should have their shorter axes placed longitudinally. It is very desirable that the compensating rings round openings in flat surfaces should be made of **L** or **T** iron.

*Circular Furnaces.*

The following formulæ may be used to determine the working pressure when the longitudinal joints are welded or made with a butt strap:—

P = working pressure per square inch.

L = length in feet.

T = thickness of plate in inches.

D = diameter in inches.

$$P = \frac{90000 \times T^2}{(L + 1) \times D}$$

Without the Board's special approval of the plans, the pressure is in no case to exceed

$$\frac{8000 \times T}{D}$$

The length to be measured between the rings, if the furnace is made with rings.

If the longitudinal joints, instead of being butted, are lap-jointed in the ordinary way, then 70000 is to be used instead of 90000, excepting only where the lap is bevelled and so made as to give the flues the form of a *true* circle, when 80000 may be used.

When the material or the workmanship is not of the best quality, the constants given above must be reduced—that is to say, the 90000 will become 80000, the 80000 will become 70000, and the 70000 will become 60000.

One of the conditions of best workmanship must be that the joints are either double-riveted with single butt-straps or single-riveted with double butt-straps, and the holes drilled after the bending is done and when in place, and afterwards taken apart, the burr on the holes taken off, and the holes slightly counter-sunk from the outside.

*Cylindrical Superheaters.*

The strength of the joints and the factor of safety is found in a similar manner as for cylindrical boilers and steam receivers, but instead of using 51,520 lbs. as the tensile strength of the iron, 30,000 lbs. is adopted, unless, where the heat or flame impinges at or nearly at right angles to the plate, the 22,400 lbs. is substituted.

In all cases the internal steam pipes should be so fitted that the steam in flowing to them will pass over all the plates exposed to the impact of heat or flame. Superheaters that can be shut off from the main boilers must be fitted with a Parliamentary safety valve of sufficient size, but the least size which will be passed without special written authority is 3 inches diameter.

The flat ends of all boilers, as far as the steam space extends, and the ends of superheaters should be fitted with shield or baffle plates where exposed to the hot gases in the uptake.

*Gauges, &c.*

*Each* boiler must be fitted with a glass water-gauge, at least two test cocks, and steam gauge; boilers that fire both ends, and those of unusual width, must have water gauges and test cocks at each end or side, as the case may be. When a steamer has more than one boiler, and those boilers are fitted with stop valves, each boiler must be treated as a separate one, and have all the requisite fittings.

*Hydraulic Tests.*

All new boilers, and boilers that have been taken out of ships for thorough repair, must be tested by hydraulic pressure up to at least double the working pressure that will be allowed previous to the boilers being replaced in position to test the workmanship, &c.; but the working pressure is to be determined by the stay power, thickness of plates, and strength of riveting, &c.

## SAFETY VALVES.

*Provisions of the Act as regards Safety Valves.*

Every steamship of which a survey is required by the Act must be provided with a safety valve upon each boiler, so constructed as to be out of the control of the engineer when the steam is up; and if such valve is in addition to the ordinary valve, it shall be so constructed as to have an area not less, and a pressure not greater, than the area of and pressure on that valve.

*Area of Safety Valves.*

So long as half a square inch of area of safety valve for each square foot of grate surface is provided, it is a matter of indifference whether it be comprised in one valve or two or more valves on the same boiler. Ordinary valves of half a square inch area to the foot of grate surface may be left without lock and key, provided that the valve required by the Act to be locked up is of the same area, and is loaded to a like pressure; but if the whole proportion of half an inch to the foot be distributed over two or more valves, and if they are all placed under lock and key, there will be no necessity to require an equal area in unlocked valves.

*Spring Safety Valves.*

Spring safety valves may be fitted in passenger steamers instead of dead-weighted valves, provided that the following conditions are complied with:—

1. That at least two separate valves are fitted to each boiler.
2. That the valves are of the proper size.

3. That the spring and valve be so cased in that they cannot be tampered with.

4. That provision be made to prevent the valve flying off in case of the spring breaking.

5. That the requisite safety-valve area is cased in, in the usual manner of Government valves.

6. That screw lifting-gear be provided to ease all the valves, if necessary, when steam is up.

7. That the springs be protected from the steam and impurities issuing from the valves.

8. That when the valves are loaded by direct springs, the compressing screw abuts against a metal stop or washer when the load sanctioned by the surveyor is on the valve.

9. That the size of the steel of which the spring is made is found by the following formula:—

#### FORMULA.

$D$  = diameter or side of square of the wire in inches.

$d$  = diameter of the spring, from centre to centre of wire, in inches.

$s$  = load on the spring in lbs.

$k$  = constant = 8000 for round and 11000 for square steel.

$$D = \sqrt[3]{\frac{(s + d)}{k}}$$

*Note.*—The accumulation of pressure should not exceed 10 per cent. of the loaded pressure.

#### MACHINERY.

##### *Cocks, Valves, and Pipes communicating with Ship's Side.*

All inlets or outlets in the bottom or side of a vessel, near to, at, or below the load water-line, must have cocks or valves fitted between the pipes and the ship's side or bottom. Such cocks or valves must be attached to the skin of the ship, and be so arranged that they can be easily and expeditiously opened or closed at any time.

All blow-off cocks and sea connections are to be fitted with a guard over the plug, with a feather-way in the same, and a key on the spanner, so that the spanner cannot be taken out unless the plug or cock is closed. One cock is to be fitted to the boiler, and another cock on the skin of the ship or on the side of the Kingston valve.

In all cases where pipes are so led or placed that water can run from the boiler or the sea into the bilge, either by accidentally or intentionally leaving a cock or valve open, they should be fitted with a non-return valve and a screw, not attached, but which will set the valve down in its seat when



- 1 screw jack and 1 fitter's vice.
- Suitable blocks and tackling for lifting weights.
- 1 dozen files, assorted, and handles for the same.
- 1 set of drifts or expanders for boiler tubes.

1 set of safety-valve springs, if so fitted, for every four valves; if there are not four valves, then at least one set of springs must be carried.

And a set of engineer's tools suitable for the service, including hammers and chisels for vice and forge, solder and soldering iron, sheets of tin and copper, spelter, muriatic acid or other equivalent, &c. &c.

Size of Shafts.

Main and tunnel and propeller shafts should be of at least the diameter as found by the following formulæ:—

FORMULA FOR COMPOUND ENGINE WITH TWO CYLINDERS.

- s = diameter of shaft in inches.
- D = diameter of high-pressure cylinder in inches.
- d = diameter of low-pressure cylinder in inches.
- P = boiler pressure.
- C = length of crank in inches.
- k = constant from following table.

$$s = \sqrt[3]{\frac{(D^2 \times P) + (d^2 \times 15)}{k}} C$$

FORMULA FOR ORDINARY CONDENSING ENGINES WITH TWO CYLINDERS, WHEN THE PRESSURE IS NOT LOW.

- s = diameter of shaft in ins.
- D = diameter of cylinder in ins.
- P = boiler pressure in lbs.
- C = length of crank in ins.
- k = constant from following table.

$$s = \sqrt[3]{\frac{D^2 \times P \times 2}{k}} C$$

TABLE GIVING THE VALUES OF THE CONSTANTS FOR THE FOREGOING FORMULA.

| Angle between Cranks | Value of k for Crank and Propeller Shafts | Value of k for Tunnel Shafts | Angle between Cranks | Value of k for Crank and Propeller Shafts | Value of k for Tunnel Shafts |
|----------------------|---|------------------------------|----------------------|---|------------------------------|
| 90°                  | 2,468                                     | 2,880                        | 140°                 | 1,858                                     | 2,168                        |
| 100°                 | 2,279                                     | 2,659                        | 150°                 | 1,806                                     | 2,108                        |
| 110°                 | 2,131                                     | 2,487                        | 160°                 | 1,772                                     | 2,068                        |
| 120°                 | 2,016                                     | 2,352                        | 170°                 | 1,752                                     | 2,045                        |
| 130°                 | 1,926                                     | 2,248                        | 180°                 | 1,746                                     | 2,037                        |

*Stores to be Carried with Distilling Apparatus.*

The following list of tools and material must be provided for distilling apparatus:—

- 1 set of stoking tools.
- 1 scaling tool.
- 1 spanner for boiler doors.
- 1 set of fire bars, suitable for boiler.
- 1 14-inch flat bastard file.
- 1 14-inch half-round file.
- 1 10-inch round file.
- 3 file handles.
- 2 hand coal chisels.
- 1 chipping hammer.
- 1 pair of patent gas tongs.
- 1 soldering iron.
- 10 lbs. of solder.
- 2 lbs. of resin.
- 6 gauge glasses.
- 24 india-rubber gauge-glass washers.
- 30 bolts and nuts, assorted.
- 1 slide rod for donkey pump.
- 5 lbs. of spun yarn.
- 10 lbs. of cotton waste.
- 1 deal box with lock complete.
- 2 gallons of machinery oil.
- 1 can for „
- 1 oil-feeder.
- 1 small bench vice.
- 1 ratchet brace.
- 4 drills, assorted.
- 1 set of dies and taps suitable for the bolts.
- 2 glass salinometers.
- 1 hydrometer and pot.
- 1 shifting spanner.
- 1 lamp for engineer.

And other articles that the particular distiller and boiler supplied may, in the surveyor's judgment, require.

**MARINE ENGINES.****CONSUMPTION OF COAL PER I.H.P.**

THE following figures may be taken as a good approximation of the consumption per I.H.P. per hour when the engines are being driven at a moderate speed:—

|                                | Compound Engine. | Expansive Engine. |
|--------------------------------|------------------|-------------------|
| Above 2,000 I.H.P.             | 2 lbs.           | 3½ lbs.           |
| Between 1,000 and 2,000 I.H.P. | 2¼ to 2½ lbs.    | 4 to 4½ lbs.      |
| Under 1,000 I.H.P.             | 2½ „ 3 „         | 4½ „ 5 „          |

*Note.*—In either class of engine the consumption per I.H.P. per hour is about ½ lb. more when going at full speed.

**WEIGHT IN CWTs. PER I.H.P.**

(*F. Proctor.*)

| I.H.P.         | Engines    | Boilers    | Screw Shafting | Spare Gear  | Extra Work | Total         |
|----------------|------------|------------|----------------|-------------|------------|---------------|
| 9,000 to 5,000 | 1·0 to 1·2 | 1·2 to 1·5 | ·25 to ·28     | ·125 to ·13 | ·13 to ·15 | 2·705 to 3·26 |
| 5,000 „ 1,000  | 1·2 „ 1·3  | 1·5 „ 1·9  | ·28 „ ·29      | ·13 „ ·20   | ·15 „ ·06  | 3·26 „ 3·75   |
| 1,000 „ 500    | 1·3        | 1·9 „ 2·8  | ·29            | ·20 „ ·29   | ·06 „ ·04  | 3·75 „ 4·75   |

*Note.*—The above weights are for expansive engines of good make; compound engines average from 10 to 20 per cent. heavier.

**CONSUMPTION OF COAL PER DAY, HOUR, &c.**

I.H.P. × ·06429 = tons per 24 hours at the rate of 6 lbs. per hour.

|              |   |   |   |    |   |
|--------------|---|---|---|----|---|
| „ × ·05853 = | „ | „ | „ | 5½ | „ |
| „ × ·05357 = | „ | „ | „ | 5  | „ |
| „ × ·04821 = | „ | „ | „ | 4½ | „ |
| „ × ·04286 = | „ | „ | „ | 4  | „ |
| „ × ·03750 = | „ | „ | „ | 3½ | „ |
| „ × ·03214 = | „ | „ | „ | 3  | „ |
| „ × ·02679 = | „ | „ | „ | 2½ | „ |
| „ × ·02143 = | „ | „ | „ | 2  | „ |
| „ × ·01071 = | „ | „ | „ | 1  | „ |

**STOWAGE OF COAL, &c.**

The Admiralty allowance for coal = 48 cubic feet per ton of 2,700 lbs. = 40½ cubic feet per ton of 2,240 lbs., which is the average generally allowed for coal-bunker space.

The bulk of wood is about 6 times as much as an equivalent of coal.

A cord of wood = 4 feet × 4 feet × 8 feet = 128 cubic feet.

A cubic foot of tallow weighs about 59 lbs.

|   |   |       |   |   |    |   |
|---|---|-------|---|---|----|---|
| „ | „ | waste | „ | „ | 11 | „ |
| „ | „ | oil   | „ | „ | 56 | „ |





TABLE II., GIVING A FEW PARTICULARS OF SOME MARINE SCREW ENGINES AS MANUFACTURED BY MESSRS. MAUDSLAY, SONS, AND FIELD.

| PARTICULARS  | 'Paiki Sherrif,'<br>F. ♂<br>Common<br>Engine | 'Europe,'<br>M. Com-<br>pound<br>Engine | 'City of<br>Genoa,'<br>F. Common<br>Engine | 'Guana-<br>bara,'<br>F. Common<br>Engine | 'Druid,'<br>A. Common<br>Engine | 'Sirus,'<br>A. Com-<br>pound<br>Engine | 'Nymphe'<br>A.<br>3-cyl.<br>Engine | 'Cerberus,'<br>A. ♂ |
|--|--|---|--|--|---------------------------------|--|------------------------------------|---------------------|
| Nominal horse-power. Collective                      | 600  | 580                                     | 506  | 500                                      | 350                             | 350                                    | 300                                | 250                 |
| Indicated " " "                                      | 3,900  | 3,946                                   | —  | 3,000                                    | 2,373                           | 2,325                                  | 2,156                              | 1,500               |
| Length of stroke in ft. and ins.                     | 2 6  | 4 3                                     | 3 6  | 3 0                                      | 2 9                             | 2 9                                    | 2 6                                | 2 3                 |
| No. of revolutions per minute                        | 95   | 63                                      | 60   | 85                                       | 96                              | 96                                     | 102                                | 100                 |
| " cylinders  | Four   | Four                                    | Two  | Two                                      | Two                             | Four                                   | Three                              | Four                |
| Diameter of cylinders in ins.                        | 65   | { 2-41 }<br>{ 2-75 }                    | 66   | 78                                       | 67                              | { 2-34 }<br>{ 2-75 }                   | 55                                 | 43                  |
| " " propeller in ft. and ins.                        | 14 0   | 19 0                                    | 17 0                                       | 16 0                                     | 15 0                            | 15 0                                   | 15 0                               | 12 0                |
| Pitch " " shaft in ins.                              | 14 0   | 28 0                                    | 20 6                                       | 20 3                                     | 15 6                            | 15 6                                   | 13 0                               | 10 3                |
| Diameter " " " "                                     | 12-5   | 16-25                                   | 14-25                                      | 15-0                                     | 12-5                            | 12-25                                  | 11-5                               | 8-5                 |
| Weight of boilers in tons                            | 116-85                                       | 151-0                                   | 96-45                                      | 101-0                                    | 70-0                            | 64-7                                   | 61-7                               | 62-8                |
| " water in boilers in tons                           | 88-5   | 112-0                                   | 80-0                                       | 73-0                                     | 48-0                            | 46-0                                   | 45-0                               | 43-9                |
| Total weight of machinery and water in tons          | 565-0  | 678-0                                   | 390-0                                      | 439-0                                    | 304-0                           | 302-0                                  | 282-0                              | 260-0               |
| No. of boilers                                       | Four   | Six                                     | Four                                       | Four                                     | Four                            | Six                                    | Four                               | Four                |
| Length of boilers in ft. and ins.                    | 20 0   | 16 7                                    | 15 10                                      | 20 6                                     | 14 6                            | 10 0                                   | 13 0                               | 12 0                |
| Breadth " " "  | 12 0   | 10 7                                    | 11 6                                       | 10 4                                     | 11 2                            | 9 0                                    | 10 9                               | 11 0                |
| Height " " "   | 12 0   | 10 7                                    | 12 4                                       | 12 0                                     | 9 10                            | 10 0                                   | 10 0                               | 11 9                |
| Steam pressure in cylinders in lbs. per sq. in.      | —  | —                                       | —  | —  | 20-8                            | —                                      | 19-8                               | —                   |
| " " " boilers  | 30   | 60                                      | 25   | 30                                       | 80                              | 50                                     | 30                                 | 28                  |
| No. of funnels                                       | One  | Two                                     | One  | One                                      | One                             | One                                    | One                                | One                 |
| Diameter of funnels in ft. and ins.                  | 8 6  | 6 6                                     | 7 8  | 9 0                                      | 6 6                             | 6 0                                    | 6 0                                | 6 2                 |
| Height of funnels from top of boiler in ft. and ins. | 54 6   | 53 0                                    | 50 0                                       | 43 0                                     | 37 0                            | 36 0                                   | 32 6                               | 35 0                |
| Total area of fire grates in sq. ft.                 | 466  | 464                                     | 382  | 455                                      | 256                             | 210                                    | 210                                | 250                 |
| " " heating surface in sq. ft.                       | 11,070                                       | 11,120                                  | 11,354                                     | 11,070                                   | 6,740                           | 5,500                                  | 5,740                              | 5,420               |

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TABLE IV., GIVING A FEW PARTICULARS OF SOME MARINE SOREW ENGINES AS MANUFACTURED  
BY MESSRS. MAUDSLAY, SONS, AND FIELD.

| PARTICULARS  | 'Viper,'<br>A. ©<br>Common<br>Engine | 'Parna-<br>hyba,'<br>F.<br>Common<br>Engine | 'Italia,'<br>M.<br>3-cyl.<br>Engine | 'Trafal-<br>gar,'<br>M.<br>Comp.<br>Engine | 'Bos-<br>dicea,'<br>M.<br>Comp.<br>Engine | 'Tcher-<br>kash,'<br>M.<br>Common<br>Engine | 'Gos-<br>hawk,'<br>A.<br>Comp.<br>Engine | 'Eliza-<br>beth,'<br>A.<br>Comp.<br>Engine |
|--|--------------------------------------|---|-------------------------------------|--|---|---|--|--|
| Nominal horse-power. Collective                        | 160                                  | 150   | 150                                 | 180  | 125                                       | 120   | 60                                       | 30   |
| Indicated " " "  | 708                                  | 900   | 625                                 | 769  | 515                                       | 556   | 483                                      | 243  |
| Length of stroke in ft. and ins.                       | 1 6                                  | 2 0   | 2 6                                 | 2 9  | 2 6                                       | 3 0   | 1 6                                      | 1 4  |
| No. of revolutions per minute                          | 110                                  | 100   | 75                                  | 82   | 56  | 60  | 184                                      | 152  |
| " cylinders  | Four                                 | Two   | Three                               | Two  | Two                                       | Two   | Two                                      | Two  |
| Diameter of cylinders in ins.                          | 32                                   | 48  | 40                                  | { 1-29<br>1-56 }                           | { 1-29<br>1-56 }                          | 45  | { 1-28<br>1-48 }                         | 1-21<br>1-36                               |
| " " propeller in ft. and ins.                          | 9 0                                  | 10 3  | 12 0                                | 13 0                                       | 14 9                                      | 14 0  | 9 0                                      | 6 0  |
| Pitch " " shaft in ins.                                | 12 0                                 | 14 9  | 17 6                                | 14 6                                       | 15 0                                      | 16 0  | 9 4                                      | 8 9  |
| Diameter " " in ins.                                   | 6-75                                 | 9-75  | 9-25                                | 9-25                                       | 9-25                                      | 9-5   | 6-5                                      | 5-25                                       |
| Weight of boilers in tons                              | 36-05                                | 43-5  | 22-5                                | 30-0                                       | 29-35                                     | 24-9  | 15-75                                    | 8-15                                       |
| " water in boilers in tons                             | 30-0                                 | 28-6  | 17-55                               | 19-7                                       | 19-6                                      | 17-5  | 11-4                                     | 6-3  |
| Total weight of machinery and water in tons            | 117-5                                | 156-0                                       | 119-0                               | 135-0                                      | 128-0                                     | 123-0                                       | 74-0                                     | 45-0                                       |
| No. of boilers   | Two                                  | Four  | One                                 | Two  | Two                                       | One   | Two                                      | One  |
| Length of boilers in ft. and ins.                      | 19 8                                 | 13 6  | 15 9                                | 10 4                                       | 10 6                                      | 16 0  | 15 0                                     | 7 11                                       |
| Breadth " " "  | 10 6                                 | 8 6   | 11 0                                | 9 0  | 9 0                                       | 11 4  | 8 6                                      | 7 6  |
| Height " " "   | 7 6                                  | 7 2   | 14 6                                | 10 4                                       | 10 6                                      | 13 0  | 6 6                                      | 7 11                                       |
| Steam pressure in cylinders in lbs. per sq. in.        | 21-9                                 | —   | 14-6                                | —  | —   | 16  | —  | —  |
| " " boilers  | 25                                   | 30  | 25                                  | 60   | 70  | 30  | 60                                       | 60   |
| No. of funnels   | One                                  | One   | One                                 | One  | One                                       | One   | One                                      | One  |
| Diameter of funnels in ft. and ins.                    | 4 10                                 | 5 0   | 3 4                                 | 4 6  | 4 4                                       | 4 0   | 2 9                                      | 2 6  |
| Height of funnels above top of boilers in ft. and ins. | 32 0                                 | 36 0  | 32 0                                | 38 0                                       | 38 0                                      | 36 0  | 28 6                                     | 24 0                                       |
| Total area of fire grates in sq. ft.                   | 113                                  | 140   | 72                                  | 66   | 66  | 93  | 45                                       | 23   |
| " " heating surface in sq. ft.                         | 3,310                                | 3,450                                       | 2,255                               | 2,500                                      | 2,280                                     | 2,400                                       | 1,220                                    | 610  |

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**SEASONING TIMBER.***Natural Seasoning.*

THIS is performed by exposing the timber freely to the air in a dry place sheltered from the wind and sun, and so stacked as to admit of the air passing freely over all the surfaces of the pieces. Timber for carpenter's work will require about two years to season it properly; for joiner's work, about four years, or even longer.

*Seasoning by a Vacuum.*

The timber is placed in a chamber from which the air is exhausted, heat being at the same time employed so as to vaporise the exuded juices, the vapour being conveyed away by means of pipes surrounded by cold water.

*Seasoning by Hot Air (Davidson).*

The timber is placed in a chamber and exposed to a current of hot air impelled by a fan at the rate of about 100 feet per second, the air passages, fan, and chamber being so arranged that one-third of the volume of air in the chamber is blown through it per minute.

The temperature of the hot air varies for different kinds of timber as follows:—

|                            |           |
|----------------------------|-----------|
| Oak of any dimensions      | 105° F.   |
| Bay mahogany 1" boards     | 280°-300° |
| Leaf woods in logs         | 90°-100°  |
| Pine woods in thick pieces | 120°      |

*Water Seasoning.*

This is done by immersing the timber in water—if shallow and salt it is better than fresh—and letting it remain there for periods averaging from 10 to 20 years, but it is sometimes only allowed to remain 14 days, when it is taken out and stood upright in some sheltered place where the air can get at it thoroughly, so as to render it quite dry. Sometimes it is thoroughly boiled or steamed for a day or two instead of being immersed in cold water for longer periods. All these processes tend rather to injure the strength of the wood, making it softer, although it tends to prevent cracking, warping, and shrinking.

*Note.*—Slowly seasoned timber is tougher and more elastic than when it is rapidly dried.

Seasoning by heat alone is very injurious to timber, as it produces a hard crust on the surface and prevents the moisture from evaporating.

For joiner's work and carpentry natural seasoning should have the preference.

## PRESERVING TIMBER

### CREOSOTING. (*Bethell.*)

THE timber is first well dried, either by being freely exposed to the thorough circulation of the air or dried in an oven at a temperature varying from 90° to 100° Fahr., depending on the kind of timber.

One process is then to place the timber in a strong iron cylinder, and subject it to a vacuum of 6 to 12 lbs. per square inch for 30 or 40 minutes. The creosote is then allowed to flow in, and a pressure put upon it, varying from 100 to 150 lbs. per square inch, for about 1 to 2½ hours. The other process consists in simply immersing the timber in an open tank containing hot creosote, the temperature being kept up to about 120° to 150° Fahr., and left for some time to the natural process of absorption.

*Note.*—Ordinary fir timber absorbs from 8 to 10 lbs. of creosote per cubic foot of timber; red pine, from 15 to 16 lbs.; memel, from 10 to 12 lbs.; oak, from 4 to 5 lbs. This method of preserving timber is the most generally used; it is a sure preventive against the attack of the teredo and other marine worms.

### IMPREGNATION WITH METALLIC SALTS.

#### *Kyan's Process.*

This consists in immersing the timber in a solution of bichloride of mercury diluted with about 100 to 150 parts of water, or about 1 to ⅔ of a lb. of the salt to 10 gallons of water. Twenty-four hours are usually allowed for each inch in thickness for boards, &c.

#### *Margary's Process.*

Margary employed sulphate of copper diluted with about 40 to 50 parts of water, applied with pressure varying from 15 to 30 lbs. per square inch for 6 or 8 hours.

#### *Burnett's Process.*

A solution of about 1 lb. of chloride of zinc to 4 or 5 gallons of water is injected and applied with a pressure varying from 100 to 120 lbs. per square inch for about 15 minutes. The timber is then taken out and allowed to dry for about 14 days. The timber should remain immersed for about 2 days for every inch in thickness.

#### *Payne's Process.*

Payne's process consists in impregnating the timber with a strong solution of sulphate of iron, and afterwards forcing in a solution of any of the carbonate alkalies.

**TIMBER MEASURE.**

IN estimating quantities of timber duodecimals are usually employed—that is, the foot, inch, seconds, &c., are each divided into twelve parts instead of ten, as in common decimal fractions; so that by this means feet, inches, and seconds can be directly multiplied by feet, inches, and seconds. Thus:—

12 inches make 1 foot.  
12 seconds make 1 inch.

12 thirds make 1 second.  
12 fourths make 1 third.

And—

Feet multiplied by feet give feet.  
Feet multiplied by inches give inches.  
Feet multiplied by seconds give seconds.  
Inches multiplied by inches give seconds.  
Inches multiplied by seconds give thirds.  
Seconds multiplied by seconds give fourths, &c.

**TO MULTIPLY BY DUODECIMALS.**

**RULE.**—Place the several denominations of the multiplier directly under the corresponding denominations of the multiplicand.

Then multiply each denomination in the multiplicand by the number of feet in the multiplier, and place each product under its corresponding denomination in the multiplicand, always carrying one for every twelve.

In the same manner multiply by the number of inches, and set each product one place farther to the right hand.

Then multiply by the number of seconds, and set each product another place farther to the right hand.

Thus proceed with all the other denominations, and the sum of all the products will be the whole product required.

*Example 1.*

Multiply 3 ft.  $6\frac{1}{2}$  ins. by  
2 ft.  $5\frac{1}{4}$  ins.

|             | ft.   | ins. | secs. |   |   |
|-------------|-------|------|-------|---|---|
|             | 3     | 6    | 6     |   |   |
|             | 2     | 5    | 3     |   |   |
|             | <hr/> |      |       |   |   |
|             | 7     | 1    | 0     |   |   |
|             | 1     | 5    | 8     | 6 |   |
|             |       |      | 10    | 7 | 6 |
|             | <hr/> |      |       |   |   |
| <i>Ans.</i> | 8     | 7    | 7     | 1 | 6 |

*Example 2.*

Multiply 2 ft. 7 ins. 4. secs.  
8 thirds by 1 ft. 2 ins. 3 secs.  
3 thirds.

|      | ft.   | ins. | secs. | thrds. |    |   |   |
|------|-------|------|-------|--------|----|---|---|
|      | 2     | 7    | 4     | 8      |    |   |   |
|      | 1     | 2    | 3     | 3      |    |   |   |
|      | <hr/> |      |       |        |    |   |   |
|      | 2     | 7    | 4     | 8      |    |   |   |
|      |       | 5    | 2     | 9      | 4  |   |   |
|      |       |      | 7     | 10     | 2  | 0 |   |
|      |       |      |       | 7      | 10 | 2 | 0 |
| Ans. | <hr/> |      |       |        |    |   |   |
|      | 3     | 1    | 2     | 11     | 4  | 2 | 0 |

# TO FIND THE SOLID CONTENTS OF ROUND OR UNSQUARED TIMBER.

RULE 1.—Multiply the square of the quarter-girt by the length, and the product will be the solid contents.

RULE 2.—Find the area in the following table which corresponds to the quarter-girt in inches, and multiply it by the length of the timber in feet; the product will be the solid contents in cubic feet and decimals of a cubic foot.

## Examples.

What is the solid contents of a tree whose girt is 60 inches and whose length is 18 feet?

BY RULE 1.

$$\begin{array}{r}
 4)60 \text{ ft. ins.} \\
 \text{ins. } 15 = 1 \quad 3 \\
 \quad \quad 1 \quad 3 \\
 \quad \quad \hline \quad \quad 1 \quad 3 \\
 \quad \quad \quad \quad 3 \quad 9 \\
 \quad \quad \quad \quad \hline \text{ft. } 1 \quad 6 \quad 9 \\
 \\
 \begin{array}{r}
 \text{ft. ins. secs.} \\
 18 \quad 0 \quad 0 \\
 1 \quad 6 \quad 9 \\
 \hline
 18 \quad 0 \quad 0 \\
 9 \quad 0 \quad 0 \\
 1 \quad 1 \quad 6 \\
 \hline
 \text{Ans. } 28 \cdot 1 \quad 6
 \end{array}
 \end{array}$$

BY RULE 2.

$$\begin{array}{r}
 4)60 \\
 \quad \quad 15 \text{ ins.} \\
 \quad \quad \hline
 \text{Corresponding to 15 ins. in} \\
 \text{the table is 1.562 feet, and} \\
 \\
 \begin{array}{r}
 \text{sq. ft.} \\
 1.562 \\
 \quad \quad 18 \\
 \hline
 28.112 \\
 \hline
 \text{Ans. } 28.112
 \end{array}
 \end{array}$$

TABLE OF CONSTANTS FOR MEASURING TIMBER.

| Girt<br>4<br>Ins. | Area.<br>Sq. Ft. | Girt<br>4<br>Ins. | Area.<br>Sq. Ft. | Girt<br>4<br>Ins. | Area.<br>Sq. Ft. | Girt<br>4<br>Ins. | Area.<br>Sq. Ft. | Girt<br>4<br>Ins. | Area.<br>Sq. Ft. |
|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|
| 6                 | ·250             | 9 $\frac{3}{4}$   | ·660             | 13 $\frac{1}{2}$  | 1.266            | 17 $\frac{1}{4}$  | 2.066            | 24                | 4.000            |
| 6 $\frac{1}{4}$   | ·271             | 10                | ·694             | 13 $\frac{3}{4}$  | 1.313            | 17 $\frac{1}{2}$  | 2.127            | 24 $\frac{1}{2}$  | 4.168            |
| 6 $\frac{1}{2}$   | ·293             | 10 $\frac{1}{4}$  | ·780             | 14                | 1.361            | 17 $\frac{3}{4}$  | 2.188            | 25                | 4.340            |
| 6 $\frac{3}{4}$   | ·316             | 10 $\frac{1}{2}$  | ·766             | 14 $\frac{1}{4}$  | 1.410            | 18                | 2.250            | 25 $\frac{1}{2}$  | 4.516            |
| 7                 | ·340             | 10 $\frac{3}{4}$  | ·808             | 14 $\frac{1}{2}$  | 1.460            | 18 $\frac{1}{2}$  | 2.377            | 26                | 4.694            |
| 7 $\frac{1}{4}$   | ·365             | 11                | ·840             | 14 $\frac{3}{4}$  | 1.511            | 19                | 2.507            | 26 $\frac{1}{2}$  | 4.877            |
| 7 $\frac{1}{2}$   | ·391             | 11 $\frac{1}{4}$  | ·879             | 15                | 1.563            | 19 $\frac{1}{2}$  | 2.641            | 27                | 5.063            |
| 7 $\frac{3}{4}$   | ·417             | 11 $\frac{1}{2}$  | ·918             | 15 $\frac{1}{4}$  | 1.615            | 20                | 2.778            | 27 $\frac{1}{2}$  | 5.252            |
| 8                 | ·444             | 11 $\frac{3}{4}$  | ·959             | 15 $\frac{1}{2}$  | 1.668            | 20 $\frac{1}{2}$  | 2.918            | 28                | 5.444            |
| 8 $\frac{1}{4}$   | ·473             | 12                | 1.000            | 15 $\frac{3}{4}$  | 1.723            | 21                | 3.063            | 28 $\frac{1}{2}$  | 5.641            |
| 8 $\frac{1}{2}$   | ·502             | 12 $\frac{1}{4}$  | 1.042            | 16                | 1.778            | 21 $\frac{1}{2}$  | 3.210            | 29                | 5.840            |
| 8 $\frac{3}{4}$   | ·532             | 12 $\frac{1}{2}$  | 1.085            | 16 $\frac{1}{4}$  | 1.834            | 22                | 3.361            | 29 $\frac{1}{2}$  | 6.043            |
| 9                 | ·563             | 12 $\frac{3}{4}$  | 1.129            | 16 $\frac{1}{2}$  | 1.891            | 22 $\frac{1}{2}$  | 3.516            | 30                | 6.250            |
| 9 $\frac{1}{4}$   | ·594             | 13                | 1.174            | 16 $\frac{3}{4}$  | 1.948            | 23                | 3.674            | 31                | 6.674            |
| 9 $\frac{1}{2}$   | ·626             | 13 $\frac{1}{4}$  | 1.219            | 17                | 2.007            | 23 $\frac{1}{2}$  | 3.835            | 32                | 7.111            |



## TIMBER MEASURES.

|   |   |   |  |  |  |
|---|---|---|--|--|--|
| 40 cubic feet of unhewn timber                            | . | . |  |  |  |
| 50 " " squared "  | . | . |  |  |  |
| 600 superficial feet of 1-inch planks or deals            |   |   |  |  |  |
| 400 " " $1\frac{1}{2}$ " "                                |   |   |  |  |  |
| 300 " " 2 " "   |   |   |  |  |  |
| 240 " " $2\frac{1}{2}$ " "                                |   |   |  |  |  |
| 200 " " 3 " "   |   |   |  |  |  |
| 170 " " $3\frac{1}{2}$ " "                                |   |   |  |  |  |
| 150 " " 4 " "   |   |   |  |  |  |
| 100 " " make 1 square of boarding, flooring, &c.          |   |   |  |  |  |
| 120 deals = 1 hundred.                                    |   |   |  |  |  |
| Battens are 7 ins. wide, deals 9 ins., and planks 11 ins. |   |   |  |  |  |

## WASTE ON CONVERTING TIMBER.

|                   |                 |             |                 |
|-------------------|-----------------|-------------|-----------------|
| African oak       | = 100 per cent. | English oak | = 200 per cent. |
| American elm      | = 15 "          | " " plank   | = 50 "          |
| Dantzic fir plank | = 25 "          | Greenheart  | = 25 "          |
| " oak             | = 50 "          | Mahogany    | = 30 "          |
| " " plank         | = 40 "          | Quebec oak  | = 10 "          |
| English elm       | = 200 "         | Teak        | = 15 "          |

Dantzic fir, when cut from planks . . . = 10 per cent.

Yellow pine, when cut for head and stern work = 200 "

" " " decks . . . = 10 "

## PLASTERING.

|                               | 1 In. Thick.                | $\frac{3}{4}$ In. Thick. | $\frac{1}{2}$ In. Thick. |
|-------------------------------|-----------------------------|--------------------------|--------------------------|
| 1 bushel of cement will cover | $1\frac{1}{2}$ sup. yd.,    | $1\frac{1}{2}$ sup. yd., | $2\frac{1}{4}$ sup. yds. |
| 1 do. and 1 of sand           | " $2\frac{1}{4}$ sup. yds., | 3 sup. yds.,             | $4\frac{1}{2}$ "         |
| 1 " 2 " "                     | " $3\frac{1}{2}$ "          | $4\frac{1}{2}$ "         | $6\frac{3}{4}$ "         |
| 1 " 3 " "                     | " $4\frac{1}{2}$ "          | 6 "                      | 9 "                      |

1 cubic yd. of lime, 2 yds. of sand, and 3 bushels of hair will cover  $\left\{ \begin{array}{l} 75 \text{ sup. yds. on brick.} \\ 70 \text{ " " earth.} \\ 60 \text{ " " laths.} \end{array} \right.$

## BRICKLAYING.

|                     | Size in Ins.   | Weight in Lbs. |
|---------------------|--|----------------|
| London stock bricks | $8\frac{3}{4} \times 4\frac{1}{4} \times 2\frac{3}{4}$ | 6.81           |
| Red kiln            | ditto.   | 7.00           |
| Welsh fire          | $9 \times 4\frac{1}{2} \times 2\frac{3}{4}$            | 7.84           |
| Paving              | $9 \times 4\frac{1}{2} \times 1\frac{3}{4}$            | 5.00           |
| Square tiles        | $9\frac{3}{4} \times 9\frac{3}{4} \times 1$            | 5.70           |
| "                   | $6 \times 6 \times 1$                                  | 2.16           |

A rod of brick-work =  $16\frac{1}{2}$  ft.  $\times$   $16\frac{1}{2}$  ft.  $\times$   $1\frac{1}{2}$  brick thick.

" " = 306 cubic ft. =  $11\frac{1}{3}$  cubic yards.

" " = 272 sup. ft.  $1\frac{1}{2}$  brick thick.

" " = 4,352 stock bricks 4 courses 1 ft. high.

" " = 4,533 " if " measure  $11\frac{1}{2}$  ins.

" " = 5,371 " laid dry.

Bricks absorb about  $\frac{1}{18}$  their weight of water.

A rod of brick-work requires about 3 cu. yds. of mortar, or  $1\frac{1}{2}$  cu. yd. of chalk lime and 3 loads of sand, or 1 cu. yd. of stone lime and  $3\frac{1}{2}$  loads of sand, or 36 bushels of cement and an equal quantity of sand.

A load of mortar or sand = 1 cubic yard.

A bag of cement = 3 bushels, a sack = 5 bushels.

A load of mortar requires about 9 bushels of lime and 1 cu. yard or load of sand.

500 bricks = 1 load. 330 stock bricks weigh 1 ton.

1,000 bricks loosely stacked occupy about 72 cu. ft.

" closely " " 56 "

Mortar is composed of 1 of lime to 3 or  $3\frac{1}{2}$  of sharp sand.

Concrete " " " 4 of gravel and 2 of sand.

Cement " " Portland cement to 3 of sand, or the cement may be used alone.

## PAINTING.

As an average  $\frac{1}{4}$  lb. of paint should be allowed per sq. yd. for the first coat, and about  $\frac{1}{6}$  lb. for each additional coat.

1 lb. of stopping should be allowed for every 20 sq. yds.

A gallon of tar and 1 lb. of pitch will cover about 12 sq. yds. the first coat, and 17 yds. each additional coat.

Priming consists of white lead and linseed oil.

Knotting " red lead and size.

Putty " Spanish whiting and linseed oil.

### White Paint.

28 lbs. white lead, 6 pints linseed oil, 2 pints turpentine, and 1 lb. litharge will cover about 100 sq. yds.

### Black Paint.

28 lbs. black paint, 10 pints linseed oil, 2 pints turpentine, and 1 lb. litharge will cover about 160 sq. yds.

### Distemper.

112 lbs. whiting, 28 lbs. dry white lead, and 7 lbs. glue, mixed with boiling water.

TABLE OF ALLOYS.

| ALLOY  | Component Parts  |                  |                 |                 |
|--|------------------|------------------|-----------------|-----------------|
|  | Copper           | Tin              | Zinc            | Brass           |
| Soft gun-metal . . . . .                         | 16               | 1                | —               | —               |
| Metal for toothed wheels . . . .                 | 10 $\frac{1}{4}$ | 1                | —               | —               |
| " " " " " " " " " " " " " "                      | 16               | 2 $\frac{1}{2}$  | —               | 2               |
| Hard bearings for machinery . . .                | 8                | 1                | —               | —               |
| Gun metal for mathematical instruments . . . . . | 12               | 1                | —               | —               |
| Speculum metal . . . . .                         | 2 $\frac{1}{2}$  | 1                | —               | —               |
| Sound copper castings . . . . .                  | 1                | —                | 32              | —               |
| Tombac, or red brass . . . . .                   | 8                | —                | 1               | —               |
| Red sheet brass . . . . .                        | 5 $\frac{1}{2}$  | —                | 1               | —               |
| Brass that solders well . . . . .                | 2 $\frac{1}{2}$  | —                | 1               | —               |
| Ordinary brass . . . . .                         | 2                | —                | 1               | —               |
| Muntz metal . . . . .                            | 1 $\frac{1}{2}$  | —                | 1               | —               |
| Extremely tenacious metal . . . .                | 16               | 1 $\frac{1}{2}$  | —               | —               |
| Bearings to stand great strains . .              | 16               | 2 $\frac{1}{2}$  | —               | —               |
| Extremely hard metal . . . . .                   | 16               | 2 $\frac{1}{2}$  | 2 $\frac{1}{2}$ | —               |
| Government standard metal . . . .                | 144              | 14 $\frac{1}{2}$ | —               | 14              |
| Articles for turning . . . . .                   | —                | 2                | —               | 1 $\frac{1}{2}$ |
| Bearings, nuts, &c. . . . .                      | —                | 2 $\frac{1}{2}$  | —               | 1 $\frac{1}{2}$ |
| Bell metal . . . . .                             | 16               | 5                | —               | —               |
| Statuary bronze . . . . .                        | 90               | 2                | 8               | —               |

TABLE OF SOLDERS.

| SOLDERS                              | Component Parts |                 |      |      |         | Flux                                  |
|--------------------------------------|-----------------|-----------------|------|------|---------|---------------------------------------|
|                                      | Copper          | Tin             | Lead | Zinc | Bismuth |                                       |
| Coarse solder for plumbers . . . . . | —               | 1               | 8    | —    | —       | Resin                                 |
| Fine solder for plumbers . . . . .   | —               | 1               | 2    | —    | —       | "                                     |
| Solder for tin . . . . .             | —               | 1 $\frac{1}{2}$ | 1    | —    | —       | " or chloride of zinc                 |
| " pewter . . . . .                   | —               | 8               | 4    | —    | 2       | " "                                   |
| " bismuth . . . . .                  | —               | 2               | 2    | —    | 1       | " "                                   |
| Brazing, soft . . . . .              | 4               | 1               | —    | 8    | —       | } Sal ammoniac or<br>chloride of zinc |
| " hard . . . . .                     | 1               | —               | —    | 1    | —       |                                       |
| " hardest . . . . .                  | 8               | —               | —    | 1    | —       |                                       |

## VARNISHES.

*Black Japan for Metals.*—Burnt umber 4 ozs., asphaltum 1 $\frac{1}{2}$  oz., boiled oil 2 quarts. Mix by heat and thin with turpentine.

*Another Recipe.*—Amber 12 ozs., asphaltum 2 ozs. Fuse by

heat; add boiled oil half a pint, resin 2 ozs.; when cooling add 16 ozs. of oil of turpentine.

*Black Japan Varnish.*—Bitumen 2 ozs., lamp black 1 oz., Turkey umber  $\frac{1}{2}$  oz., acetate of lead  $\frac{1}{2}$  oz., Venice turpentine  $\frac{1}{2}$  oz., boiled oil 12 ozs. Melt the turpentine and oil together, carefully stirring in the rest of the ingredients, previously powdered. Simmer all together for ten minutes.

*Cabinetmaker's Varnish.*—Pale shellac 700 parts, mastic 65 parts, strongest alcohol 1,000 parts by measure. Dissolve and dilute with alcohol.

*Cabinet Varnish.*—Fused copal 14 lbs., hot linseed oil 1 gallon, hot turpentine 3 gallons. Properly boiled, dries very quickly.

*Cheap Oak Varnish.*—Dissolve  $3\frac{1}{2}$  lbs. of pale resin in 1 gallon of oil of turpentine.

*Common Varnish.*—Dissolve 1 part of shellac in 7 or 8 of alcohol.

*Copal Varnish.*—Copal 800 parts, drying linseed oil 125 to 250 parts, spirit of turpentine 500 parts. Fuse the copal as quickly as possible; then add the oil, previously heated to nearly boiling point; mix well; then cool a little and add the spirit of turpentine; again mix well, and cover up till it has cooled down to  $130^{\circ}$  Fahrenheit; then strain.

*Copal Varnish for Metals, Chains, &c.*—Copal melted and dropped into water 3 ozs., gum sandarach 6 ozs., mastic  $2\frac{1}{2}$  ozs., powdered glass 4 ozs., Chio turpentine  $2\frac{1}{2}$  ozs., alcohol of 85 per cent. 1 quart. Dissolve by gentle heat.

*Gold Varnish.*—Turmeric 1 drachm, gamboge 1 drachm, oil of turpentine 2 pints, shellac 5 ozs., sandarach 5 ozs., dragon's blood 7 drachms, thin mastic varnish 8 ozs. Digest with occasional shaking for 14 days in a warm place; then set it aside to fine and pour off the clear.

*Mastic Varnish.*—Gum mastic 5 lbs., spirits of turpentine 2 gallons. Mix with gentle heat in a close vessel; then add pale turpentine varnish 3 pints.

*Table Varnish.*—Dammar resin 1 lb., spirits of turpentine 2 lbs., camphor 200 grains. Digest the mixture for 24 hours. The decanted portion is fit for immediate use.

*Another Recipe.*—Oil of turpentine 1 lb., bee's wax 2 ozs., colophony 1 drachm.

*Turpentine Varnish.*—Resin 1 part, boiled oil 1 part. Melt and then add turpentine 2 parts.

*Varnish for Iron-work.*—Dissolve 10 parts of clear grains of mastic, 5 parts of camphor, 15 parts of sandarach, and 5 parts of elemi in a sufficient quantity of alcohol, and apply cold.

*Another Recipe.*—Dissolve in about 2 lbs. of tar oil  $\frac{1}{2}$  lb. of asphaltum,  $\frac{1}{2}$  lb. of powdered resin. Mix hot in an iron kettle and apply cold.

*Varnish for Metals.*—Dissolve 1 part of bruised copal in 2 parts of strongest alcohol. It dries very quickly.

*Another Recipe.*—Copal 1 part, oil of rosemary 1 part, strongest alcohol 2 or 3 parts. This should be applied hot.

*White Copal Varnish.*—Copal 16 parts; melt, and add hot linseed oil 8 parts, spirits of turpentine 15 parts. Colour with the finest white lead.

*White Priming for Japanning.*—Parchment size  $\frac{2}{3}$ , isin-glass  $\frac{1}{3}$ .

*White Varnish.*—Tender copal  $7\frac{1}{2}$  ozs., camphor 1 oz., alcohol of 95 per cent. 1 quart; dissolve, then add 2 ozs. of mastic, 1 oz. of Venice turpentine; again dissolve, and strain.

*White Spirit Varnish.*—Sandarach 25 parts, mastic in tears 6 parts, strongest alcohol 100 parts, elemi 3 parts, Venice turpentine 6 parts. Dissolve in closely corked vessel.

#### LACQUERS.

*To make Lacquer.*—Mix the ingredients and let them stand in a warm place for 2 or 3 days, shaking them freely till the gum is dissolved, after which let them settle for 48 hours, when the clear liquor may be poured off ready for use. Pulverised glass is sometimes used to carry off impurities.

*Gold Lacquer.*—Ground turmeric 1 lb., gamboge  $1\frac{1}{2}$  oz., powdered gum sandarach  $3\frac{1}{2}$  lbs., shellac  $\frac{3}{4}$  lb., spirits of wine 2 gallons. Shake till dissolved, then strain and add 1 pint of turpentine varnish.

*Gold Lacquer for Brass not Dipped.*—Alcohol 4 gallons, turmeric 3 lbs., gamboge 3 ozs., gum sandarach 7 lbs., shellac  $1\frac{1}{2}$  lb., turpentine varnish 1 pint.

*Gold Lacquer for Dipped Brass.*—Alcohol 36 ozs., seed-lac 6 ozs., amber 2 ozs., gum gutta 2 ozs., red sandal-wood 24 grains, dragon's blood 60 grains, Oriental saffron 36 grains, pulverised glass 4 ozs.

*Good Lacquer.*—Alcohol 8 ozs., gamboge 1 oz., shellac 3 ozs., annatto 1 oz., solution of 3 ozs. of seed-lac in 1 pint of alcohol; when dissolved, add Venice turpentine  $\frac{1}{2}$  oz., dragon's blood  $\frac{1}{4}$  oz. Keep in a warm place 4 or 5 days.

*Good Lacquer for Brass.*—Seed-lac 6 ozs., amber or copal 2 ozs., best alcohol 4 gallons, pulverised glass 4 ozs., dragon's blood 40 grains, extract of red sandal-wood obtained by water 30 grains.

*Lacquer for Dipped Brass.*—Alcohol of 95 per cent. 2 gal-

lons, seed-lac 1 lb., gum copal 1 oz., English saffron 1 oz., annatto 1 oz.

*Another Recipe.*—Alcohol 12 gallons, seed-lac 9 lbs., turmeric 1 lb. to a gallon of the above mixture, Spanish saffron 4 ozs. The saffron is only to be added for bronze work.

*Lacquer Varnish.*—Add so much turmeric and annatto to lac varnish as will give the proper colour, and squeeze through a cloth.

*Pale Lacquer for Brass.*—Alcohol 8 gallons, dragon's blood 4 lbs., Spanish annatto 12 lbs., gum sandarach 13 lbs., turpentine 1 gallon.

## DIPPING ACIDS.

*Aquafortis Bronze Dip.*—Nitric acid 8 ozs., muriatic acid 1 quart, sal ammoniac 2 ozs., alum 1 oz., salt 2 ozs., water 2 gallons. Add the salt after boiling the other ingredients, and use it hot.

*Brown Bronze Dip.*—Iron scales 1 lb., arsenic 1 oz., muriatic acid 1 lb.; a piece of solid zinc, 1 oz. in weight, to be kept in while using.

*Brown Bronze Paint for Copper Vessels.*—Tincture of steel 4 ozs., spirits of nitre 4 ozs., essence of dendi 4 ozs., blue vitriol 1 oz., water  $\frac{1}{2}$  pint. Mix in a bottle. Apply it with a fine brush, the vessel being full of boiling water. Varnish after the application of the bronze.

*Bronze for all kinds of Metals.*—Muriate of ammoniac (sal ammoniac) 4 drachms, oxalic acid 1 drachm, vinegar 1 pint. Dissolve the oxalic acid first.

*Dipping Acid.*—Sulphuric acid 12 lbs., nitric acid 1 pint, nitre 4 lbs., soot 2 handfuls, brimstone 2 ozs. Pulverise the brimstone and soak it in water 1 hour; add the nitric acid last.

*Another Recipe.*—Sulphuric acid 4 gallons, nitric acid 2 gallons, saturated solution of sulphate of iron (copperas) 1 pint, solution of sulphate of copper 1 quart.

*Good Dipping Acid for Cast Brass.*—Equal quantities of sulphuric acid, nitre, and water. A little muriatic acid may be added.

*Green Bronze Dip.*—Wine vinegar 2 quarts, verditer green 2 ozs., sal ammoniac 1 oz., salt 2 ozs., alum  $\frac{1}{2}$  oz., French berries 8 ozs. Boil the ingredients together.

*Ormolu Dipping Acid for Sheet Brass.*—Sulphuric acid 2 gallons, nitric acid 1 pint, muriatic acid 1 pint, water 1 pint, nitre 12 lbs. Put in the muriatic acid last, adding a little at a time, and stir with a stick.

*Another Recipe.*—Sulphuric acid 1 gallon, sal ammoniac 1 oz.,

flowers of sulphur 1 oz., blue vitriol 1 oz., saturated solution of zinc in nitric acid mixed with equal quantity of sulphuric acid 1 gallon.

*Vinegar Bronze for Brass.*—Vinegar 10 gallons, blue vitriol 3 lbs., muriatic acid 3 lbs., corrosive sublimate 4 grains, sal ammoniac 2 lbs., alum 8 ozs.

### CEMENTS AND GLUES.

*Cement for Earthen and Glass Ware.*—Isinglass dissolved in proof spirit and soaked in water 2 ozs. (thick); dissolve in this 10 grains of very pale gum ammoniac (in tears) by rubbing them together, then add 6 large tears of gum mastic dissolved in the least possible quantity of rectified spirit.

*Cement for Iron Tubes, &c.*—Finely powdered iron 60 parts, sal ammoniac 1 pint, sufficient water to form into a paste.

*Cement for Plumbers.*—Black resin 1 part, brick dust 2 parts. Melt together.

*Cement for Leaky Boilers.*—Powdered litharge 2 parts, fine sand 2 parts, slaked lime 1 part.

*Cement for Joining Metals and Wood.*—Stir calcined plaster into melted resin until reduced to a paste; add boiled oil till brought to the consistency of honey. Apply warm.

*Cast-iron Cement.*—Clean iron borings or turnings pounded and sifted 50 to 100 parts, sal ammoniac 1 part. When it is to be applied moisten it with water.

*Turner's Cement.*—Bee's wax 1 oz., resin  $\frac{1}{2}$  oz., pitch  $\frac{1}{2}$  oz. Melt and stir in fine brick dust.

*Coppersmith's Cement.*—Powdered quick lime mixed with bullock's blood and applied immediately.

*Engineer's Cement.*—Equal weights of red and white lead mixed with drying oil. Spread on tow or canvas.

*Cement for Joining Metal and Glass.*—Copal varnish 15 parts, drying oil 5 parts, turpentine 3 parts, oil of turpentine 2 parts, liquid glue 5 parts. Melt in a bath and add 10 parts of slaked lime.

*Gasfitter's Cement.*—Resin  $4\frac{1}{2}$  parts, wax 1 part, Venetian red 1 part.

*Cement for Fastening Blades into Handles.*—Shellac 2 parts, prepared chalk 1 part, powdered and mixed.

*Cement for Pots and Pans.*—Partially melt 2 parts of sulphur and add 1 part of fine blacklead. Mix well. Pour on stone to cool, and then break it in pieces. Use like solder with an iron.

*Cement for Cracks in Stoves.*—Finely pulverised iron made into a thick paste with water glass.

*Very Strong Glue.*—Mix a small quantity of powdered chalk with melted common glue.

*Glue to Resist Moisture.*—Boil 1 lb. of common glue in 2 quarts of skimmed milk.

*Marine Glue.*—Cut caoutchouc 4 parts into small pieces and dissolve it by heat and agitation in 34 parts of coal naphtha, add to this solution 64 parts of powdered shellac, and heat the whole with constant stirring until combination takes place, then pour while hot on to metal plates to form sheets. When used must be heated to 280° Fahr.

*Liquid Glue.*—Dissolve 1 part of powdered alum in 120 parts of water; add 120 parts of glue, 10 parts of acetic acid, and 40 parts of alcohol. Digest.

*Another Recipe.*—Dissolve 2 lbs. of good glue in 2½ pints of hot water, add gradually 7 ozs. nitric acid, and mix well.

*Parchment Glue.*—Parchment shavings 1 lb., water 6 quarts; boil until dissolved, then strain and evaporate slowly until of proper consistency.

*Draughtsman's or Mouth Glue.*—Glue 5 parts, sugar 2 parts, water 8 parts. Melt in water bath and cast in moulds. For use dissolve in warm water or moisten in the mouth.

## WOOD-STAINING.

*Mahogany Colour (Dark).*—Boil together in a gallon of water ½ lb. of madder and 2 ozs. of logwood. When the wood is dry, after having been washed over with the hot liquid, go over again with a solution of 2 drachms of pearl ash in a quart of water.

*Mahogany Colour (Light).*—Wash the surface with diluted nitrous acid, and when dry use the following:—dragon's blood 4 ozs., common soda 1 oz., spirits of wine 3 pints. When well dissolved, strain.

*Rose Wood.*—Boil 8 ozs. of logwood in 3 pints of water until it is reduced to half. Apply boiling hot two or three times. The stain for the streaks is made from a solution of copperas and verdigris in a decoction of logwood.

*Ebony.*—Wash the wood with a solution of sulphate of iron; when dry, apply a mixture of logwood and nut galls; when dry, wipe with a sponge and polish with linseed oil.

## ENAMELS.

*White Enamel.*—Potash 25 parts, arsenic 14 parts, glass 13 parts, saltpetre 12 parts, flint 5 parts, and litharge 3 parts.



*Black Enamel.*—Clay 2 parts, protoxide of iron 1 part.

*Blue Enamel.*—Fine paste 10 parts, nitre 3 parts; colour with cobalt.

*Green Enamel.*—Frit 1 lb., oxide of copper  $\frac{1}{2}$  oz., red oxide of iron 12 grs.

*Yellow Enamel.*—White lead 2 parts; alum, white oxide of antimony, and sal ammoniac, each 1 part.

#### TRACING PAPER.

Nut oil 4 parts, turpentine 5 parts; mix and apply to the paper, then rub dry with flour and brush it over with ox gall.

#### INDIAN INK.

Finest lamp. black made into a thick paste with thin isinglass or gum water, and moulded into shape. It may be scented with essence of musk.

#### COPYING INK.

Add 1 oz. of moist sugar or gum to every pint of common ink.

#### STAIRCASES OR COMPANION LADDERS.

The ordinary tread of a stair or step is 8 ins., and rise  $7\frac{1}{2}$  ins.; above or below that  $\frac{1}{2}$  in. rise must be subtracted or added for every inch added to or taken from the width of tread, as the case may be.

#### CASK-GAUGING.

C = contents of cask in gallons.

D = middle or bung diameter in ins.

L = length in ins.

$d$  = end or head diameter in ins.

$C = .0009442L(2D^2 + d^2)$  considerably curved.

$C = .0009442L(2D^2 + d^2) - \frac{2}{5}(D - d)^2$  moderately curved.

$C = .0014162L(D^2 + d^2)$  very little curve.

$C = .0000315L(39D^2 + 25d^2 + 26Dd)$  any form.

#### VARIATIONS OF TIDES.

The difference in time between high water and high water averages about 49 minutes.

COMPOSITIONS OF GUNPOWDER.

|             |       |           |       |          |       |         |
|-------------|-------|-----------|-------|----------|-------|---------|
| America . . | 75    | saltpetre | 12.5  | charcoal | 12.5  | sulphur |
| Austria . . | 72    | "         | 17    | "        | 16    | "       |
| England . . | 75    | "         | 15    | "        | 10    | "       |
| France . .  | 75    | "         | 12.5  | "        | 12.5  | "       |
| Germany . . | 75    | "         | 13.5  | "        | 11.5  | "       |
| Russia . .  | 73.78 | "         | 13.59 | "        | 12.63 | "       |
| Spain . .   | 76.47 | "         | 10.78 | "        | 12.75 | "       |
| Sweden . .  | 76    | "         | 15    | "        | 9     | "       |

Average weight per cubic foot = 56.42 lbs.

Cubical contents of 100 lbs. = 1.773 cu. ft.

" " " = 3063.7 cu. ins.

TEMPERING STEEL.

| Colour.          | Temperature.  | Purpose.                              |
|------------------|---------------|---------------------------------------|
| Light straw . .  | 430°-440° . . | turning tools for metals.             |
| Dark " . .       | 470°-480° . . | tools for wood, screw taps, and dies. |
| Dark yellow . .  | 500° }        | hatchets, chipping chisels, saws, &c. |
| Light purple . . | 530° }        |                                       |
| Dark " . .       | 550°          | springs, &c.                          |

CONDUCTING POWERS OF VARIOUS SUBSTANCES.

Soft woods are not such good conductors of sound as the harder kinds. The comparison between metals is as follows:—

|               |               |             |
|---------------|---------------|-------------|
| Gold = 1,000. | Copper = 898. | Zinc = 363. |
| Silver = 973. | Iron = 374.   | Lead = 180. |

SIZES FOR LIGHTNING CONDUCTORS.

Copper rod,  $\frac{3}{4}$  in. diam.  
 „ pipe,  $1\frac{1}{8}$  in. diam.,  $\frac{1}{8}$  in. thick.  
 Iron rod galvanised,  $1\frac{3}{4}$  in. diam.  
 „ pipe,  $2\frac{1}{2}$  ins. diam.,  $\frac{5}{8}$  in. thick.  
 Flat copper bar, 3 ins. wide by  $\frac{1}{8}$  in. thick.

PRESERVATIVE FOR STEEL.

Caoutchouc 1 part, turpentine 16 parts, and boiled oil 8 parts, well mixed and boiled together. The caoutchouc should first be dissolved in the turpentine by a gentle heat, and the boiled oil then added. It should be applied with a brush, and it may be removed by turpentine.

SPECIFIC GRAVITY.

W = weight of body in air.      w = weight of body in water.

$$\text{Specific gravity} = \frac{W}{W - w}$$

If the body be lighter than water, sink it by means of some heavier substance, and then deduct the weight of the heavier substance when weighed in water by itself, and divide the weight of the light body by the remainder.

## ADMIRALTY REGULATIONS FOR THE TRANSPORT SERVICE.

Transports must have a height of 6 feet from deck to beam; in ships conveying horses, 7 feet, and 12 in hold from ceiling to beam. Measurement stores are usually rated at 40 cu. ft. to the ton; heavy stores, at 20 cwt. In freighting *store ships* the Government stipulates for the conveyance of one passenger to every 25 tons of stores (if required); at the rate of 6 tons freight for every first-class passenger, 4 for every second, and 3 for every third.

Ships conveying over 50 troops are to have a free-board of not less than 4 ins. for every registered foot of depth of hold.

The dimensions of a cabin for one officer, 30 superficial feet; for two, 42; 10 additional for every officer in addition—all independent of the bed-places, which are to be 6 feet long and 27 inches wide. The standing bed-places for one woman and two children under ten years of age, or for two women, are to be 6 feet long and 3 feet wide. All standing bed-places to be kept 3 ins. from the ship's side. Hospital accommodation, 2 or 3 per cent. of the passengers. The hammocks are to be 6 feet long; each is to have a space 9 feet long by 16 ins. wide.

The crews of transports are to be four men to every 100 tons register, with two boys in addition in every ship; paddle-wheel steamers, five men to every 200 tons gross register; screws, three to every 100 tons gross register; engineers, &c. (in addition), one man to every 15-horse power. Horses should be allowed daily 6 lbs. oats, 10 lbs. hay, half-peck or  $2\frac{1}{4}$  lbs. bran, 6 gallons of water, and such quantities of vinegar and nitre as may be required. Their stalls should be about 8 feet long,  $3\frac{1}{2}$  to 4 feet broad, 5 to 6 feet high, rising at head to  $7\frac{1}{2}$  and 8 feet.

TABLE GIVING THE TOTAL WEIGHT AND MEASUREMENT ALLOWED FOR OFFICERS.

*Naval Officers.*

|   | Cwt. | Cu. Ft. |
|---|------|---------|
| Commander-in-chief . . . . .  | 40   | 200     |
| Admiral, vice-admiral, rear admiral . . . . .   | 36   | 180     |
| Captain of fleet, commodore, inspector-general of hospitals and fleet } . . . . .   | 30   | 150     |
| Captain, chaplain . . . . .   | 26   | 130     |
| Staff captain, deputy inspector-general of hospitals and fleet, secretary to commander-in-chief or flag officer, inspector of machinery afloat, commander, staff commander, staff surgeon, lieutenant, master, surgeon, paymaster, chief engineer } . . . . . | 18   | 90      |
| Secretary to commodore, naval instructor, assistant surgeon . . . . .   | 12   | 60      |
| Sub-lieutenant, chief warrant officer, second master, assistant paymaster, engineer, assistant engineer, warrant officer, and all subordinate officers } . . . . .  | 6    | 30      |

TABLE OF THE WEIGHT OF PROVISIONS AS ALLOWED IN THE ROYAL NAVY FOR ONE MAN FOR FOURTEEN DAYS AND FOR 1,000 MEN FOR FOUR MONTHS.

| Kind of Provision | For 1 Man for 14 Days |              | For 1,000 Men for 4 Months |                            |              |              |  |  |
|-------------------|-----------------------|--------------|----------------------------|----------------------------|--------------|--------------|--|--|
|                   | Net Allowance         | Gross Weight | Net Allowance              | Tare of Casks and Packages |              | Gross Weight |  |  |
|                   |                       |              |                            |                            |              |              |  |  |
|                   | Lbs.                  | Lbs.         | T.Owt.Gr.Lb.               | T.Owt.Gr.Lb.               | T.Owt.Gr.Lb. | T.Owt.Gr.Lb. |  |  |
| Bread             | 14                    | 14.25        | 53 19 8 22                 | 0 19 1 2                   |              | 54 19 0 24   |  |  |
| Spirits           | 4.016                 | 5.0          | 15 9 8 14                  | 8 16 1 14                  |              | 19 6 1 0     |  |  |
| Salt beef         | 5.25                  | 8.78         | 20 4 8 24                  | 13 12 0 24                 |              | 33 17 0 20   |  |  |
| Salt pork         | 5.25                  | 8.48         | 20 4 8 24                  | 12 8 8 26                  |              | 32 13 8 22   |  |  |
| Flour             | 5.25                  | 11.11        | 20 5 0 9                   | 8 9 0 26                   |              | 23 14 1 7    |  |  |
| Peas              | 8.5                   | 4.125        | 13 10 0 9                  | 2 8 0 0                    |              | 15 18 0 9    |  |  |
| Oatmeal           | .75                   | .88          | 2 17 8 10                  | 0 9 8 1                    |              | 3 7 2 11     |  |  |
| Sugar             | 1.31                  | 1.601        | 5 0 8 23                   | 1 2 1 12                   |              | 6 3 1 7      |  |  |
| Cocoa             | .875                  | 1.105        | 3 7 1 21                   | 0 17 2 13                  |              | 4 5 0 6      |  |  |
| Tea               | .218                  | .295         | 0 16 8 6                   | 0 6 0 9                    |              | 1 2 8 15     |  |  |
| Vinegar           | 1.8                   | 1.59         | 5 0 0 22                   | 1 2 1 3                    |              | 6 2 1 25     |  |  |
| Tobacco           | —                     | —            | 3 11 1 20                  | 1 8 2 8                    |              | 5 0 0 0      |  |  |
| Soap              | —                     | —            | 1 15 2 24                  | 0 7 3 4                    |              | 2 8 2 0      |  |  |
| Total.            | —                     | —            | 166 5 1 4                  | 42 8 2 2                   |              | 208 13 8 6   |  |  |

TABLE OF THE WEIGHT OF PROVISIONS AS ALLOWED IN THE ROYAL NAVY FOR EACH MAN PER DIEM FOR FOURTEEN DAYS.

| Days              | Bread |      | Spirits†        |      | Beef            |      | Pork            |      | Flour           |      | Peas†           |      | Oatmeal†      |      | Sugar |      | Cocoa |      | Tea             |      | Vinegar†      |      |
|-------------------|-------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|---------------|------|-------|------|-------|------|-----------------|------|---------------|------|
|                   | Lbs.  | Pts. | Lbs.            | Pts. | Lbs.            | Pts. | Lbs.            | Pts. | Lbs.            | Pts. | Lbs.            | Pts. | Lbs.          | Pts. | Ozs.  | Pts. | Ozs.  | Pts. | Ozs.            | Pts. | Lbs.          | Pts. |
| Sunday            | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Monday            | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Tuesday           | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Wednesday         | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      |
| Thursday          | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Friday            | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Saturday          | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Sunday            | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Monday            | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Tuesday           | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Wednesday         | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      |
| Thursday          | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Friday            | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Saturday          | 1     |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$   |      | $\frac{1}{4}$ |      | 1     |      | 1     |      | $\frac{1}{4}$   |      | —             |      |
| Total for 14 days | 14    |      | 5 $\frac{1}{4}$ |      | 5 $\frac{1}{4}$ |      | 5 $\frac{1}{4}$ |      | 5 $\frac{1}{4}$ |      | 3 $\frac{1}{4}$ |      | 1             |      | 21    |      | 14    |      | 3 $\frac{1}{4}$ |      | 1             |      |

\* Bread takes 1 cu. ft. of stowage for a bag of 112 lb. = 124 cu. ft. per ton.

† One gallon of spirits = 9.16 lbs.

One gallon of vinegar = 10.4 lbs.

" peas = 8.0 "

" oatmeal = 6.0 "

TABLE GIVING THE WEIGHT, CONTENTS, AND SIZES OF PROVISION PACKAGES AS USED IN THE ROYAL NAVY.

| Provisions in Packages | Contents   | Lgth. | Diam. | Gross | Tare | Net | Provisions in Packages | Contents   | Lgth. | Diam. | Gross | Tare | Net |
|------------------------|------------|-------|-------|-------|------|-----|------------------------|------------|-------|-------|-------|------|-----|
| Biscuit                | Bags       | —     | —     | 102   | 2    | 100 | Raisins                | Barrel     | 31½   | 24½   | 400   | 70   | 336 |
|                        | ½-bags     | —     | —     | 51    | 1    | 50  |                        | ½-hogshead | 28    | 22½   | 288   | 59   | 224 |
|                        | Punchoon   | 41½   | 30    | 797   | 140  | 657 |                        | Small cask | 22    | 17    | 142   | 30   | 112 |
|                        | Hogshead   | 37    | 28    | 819   | 119  | 500 |                        | ½-hogshead | 28    | 22½   | 292   | 89   | 258 |
| Rum*                   | Barrel     | 31½   | 24½   | 421   | 88   | 333 | Oatsmeal*              | Kilderkin  | 28    | 19½   | 204   | 32   | 172 |
|                        | ½-hogshead | 28    | 22½   | 296   | 65   | 231 |                        | Small cask | 22    | 17    | 137   | 22   | 115 |
|                        | Kilderkin  | 18    | 15    | 215   | 49   | 166 | Candles, case          |            | —     | —     | 69    | 13   | 56  |
|                        | Small cask | 12    | 10    | 143   | 52   | 111 | Mustard                |            | —     | —     | 88    | 24   | 64  |
|                        | Barrel     | 31½   | 24½   | 462   | 70   | 392 |                        | ½-hogshead | 28    | 22½   | 185   | 85   | 150 |
| Sugar                  | ½-hogshead | 28    | 22½   | 339   | 59   | 280 | Pepper                 | Small cask | 20    | 17    | 89    | 29   | 60  |
|                        | Kilderkin  | 168   | 25    | 216   | 48   | 168 |                        | Punchoon   | 41½   | 30    | 864   | 140  | 724 |
|                        | Small cask | 112   | 22    | 142   | 30   | 112 |                        | Hogshead   | 28    | 22½   | 682   | 119  | 548 |
| Tea                    | Chest      | 85    | 22    | 111   | 26   | 85  | Vinegar*               | Barrel     | 31½   | 24½   | 450   | 88   | 362 |
|                        | ½-chest    | 89    | 17½   | 55    | 16   | 39  |                        | ½-hogshead | 28    | 22½   | 317   | 65   | 252 |
|                        | Tierce     | 320   | 30½   | 516   | 198  | 320 |                        | Small cask | 22    | 17    | 153   | 33   | 120 |
| Pork                   | Barrel     | 208   | 27    | 341   | 183  | 208 | Lemon                  | Case       | 35½   | —     | 179   | 107  | 72  |
|                        | Tierce     | 304   | 30½   | 502   | 198  | 304 | juices                 | ½-case     | 19    | —     | 93    | 57   | 32  |
| Beef                   | Barrel     | 208   | 27    | 355   | 147  | 208 | Tongues                | Small cask | —     | —     | 146   | 79   | 67  |
|                        | Barrel     | 40    | 31½   | 375   | 54   | 319 |                        |            | —     | —     | 92    | 47   | 45  |
| Peas*                  | Kilderkin  | 20    | 25    | 183   | 32   | 161 |                        |            | —     | —     | 229   | 69   | 160 |
|                        | Barrel     | 336   | 31½   | 388   | 52   | 336 | Tobacco                | Barrel     | 31½   | 24½   | 165   | 65   | 110 |
| Flour                  | Kilderkin  | 168   | 25    | 201   | 33   | 138 |                        | ½-hogshead | 28    | 22½   | 122   | 42   | 80  |
|                        | Barrel     | 168   | 28    | 333   | 165  | 168 |                        | Kilderkin  | 25    | 19½   | 122   | 42   | 80  |
|                        | ½-hogshead | 112   | 25    | 257   | 145  | 112 |                        | Barrel     | 31½   | 24½   | 320   | 46   | 274 |
| Suet                   | Kilderkin  | 81    | 22    | 186   | 101  | 84  | Soap                   | ½-hogshead | 28    | 22½   | 150   | 26   | 130 |
|                        | Small cask | —     | —     | —     | —    | —   |                        | Small cask | 22    | 17    | 79    | 17   | 61  |

\* The contents of the packages in which these are packed are given in gallons.



TABLE SHOWING THE NUMBER OF CUBIC FEET REQUIRED TO STOW ONE TON WEIGHT OF VARIOUS SUBSTANCES.

| Substances                     | Cu. Ft. to a Ton | Substances                   | Cu. Ft. to a Ton |
|--------------------------------|------------------|------------------------------|------------------|
| Ashes, pot and pearl . . . . . | 40               | Indigo, in cases . . . . .   | 40               |
| Ballast, Thames . . . . .      | 22               | Linseed . . . . .            | 22               |
| Barley . . . . .               | 47               | Marl . . . . .               | 47               |
| Bread, in bulk . . . . .       | 124              | Molasses . . . . .           | 124              |
| Coal, Admiralty . . . . .      | 48               | Oats, in bulk . . . . .      | 48               |
| „ Newcastle . . . . .          | 45               | Rice, in bags . . . . .      | 45               |
| „ Welsh . . . . .              | 40               | Rum, in casks . . . . .      | 40               |
| Coffee, in bags . . . . .      | 61               | Saltpetre . . . . .          | 61               |
| Cotton, compressed . . . . .   | 50               | Sand, pit . . . . .          | 50               |
| Earth mould . . . . .          | 33               | „ river . . . . .            | 33               |
| Firewood . . . . .             | 288              | Sandstone . . . . .          | 288              |
| Flax . . . . .                 | 88               | Shingle, clean . . . . .     | 88               |
| Flour, in barrels . . . . .    | 50               | Slate . . . . .              | 50               |
| Freestones . . . . .           | 16               | Sugar, in bags . . . . .     | 16               |
| Ginger . . . . .               | 80               | Tares, in bulk . . . . .     | 80               |
| Granite stone . . . . .        | 14               | Tea, in boxes . . . . .      | 14               |
| Gravel, coarse . . . . .       | 23               | Timber, hard . . . . .       | 23               |
| Hay, compressed . . . . .      | 105              | „ soft . . . . .             | 105              |
| „ uncompressed . . . . .       | 140              | Turmeric . . . . .           | 140              |
| Hemp . . . . .                 | 64               | Silk, in bales . . . . .     | 64               |
| Hides, well packed . . . . .   | 64               | „ pieces, in cases . . . . . | 64               |
| „ loosely packed . . . . .     | 84               | Wheat, in bulk . . . . .     | 84               |

TABLE GIVING THE VARIOUS SUBSTANCES WHICH IN ARE RECKONED AT 50 CUBIC FEET TO THE TONS MEASUREMENT.

|                          |                            |                     |
|--------------------------|----------------------------|---------------------|
| Apparel                  | Elephants' teeth           | Roping, in coils    |
| Arrowroot, in cases      | Ginger, in bags            | Sago, in cases      |
| Bee's wax                | Gums, in cases             | Sal ammoniac        |
| Blackwood                | Gunny bags                 | Sarsaparilla        |
| Books                    | Hemp, in bales             | Senna, in bales     |
| Borax, in cases          | Hides and skins, in bales  | Shellac, in cases   |
| Camphor, in cases        | Indigo, in cases           | Silk piece goods    |
| Cassia, all kinds        | Mace, in cases             | Skins               |
| Cigars, in boxes         | Mother-of-pearl, in cases  | Soap, in bars       |
| Cinnamon, in bales       | Musk, in cases             | Stick lac, in cases |
| Cloves, in chests        | Nutmegs, in cases or casks | Tallow              |
| Coffee, in cases or bags | Nux vomica, in bags        | Tea, in chests      |
| Coir fibre, in bales     | Raw silk, in bales         | Timber, hewn        |
| Colocynth, in cases      | Rhubarb, in cases          | Tobacco, in bales   |
| Cotton, in bales         |                            | Tortoise shells     |
| Cowries, in bags         |                            | Wines, in casks     |
| Cummin seed              |                            | Wool, in bales      |

*Note.*—In England 40 cubic feet is generally taken as a ton measurement (see *Tonnage*, p. 88).

TABLE GIVING THE WEIGHT OF SHIPS' BOATS AS USED IN  
HER MAJESTY'S NAVY.

| Boats                  | Lgth. | Breadth  | Depth    | Weight of each |                |
|------------------------|-------|----------|----------|----------------|----------------|
|                        |       |          |          | Fitted         | Unfitted       |
|                        | ft.   | ft. ins. | ft. ins. | cwt. qrs. lbs. | cwt. qrs. lbs. |
| Launch not sheathed.   | 42    | 11 0     | 2 9      | 89 2 0         | 74 3 0         |
| "                      | 40    | 10 6     | 2 9      | 82 3 14        | 67 1 14        |
| Pinnace                | 32    | 8 9      | 2 2      | 48 2 14        | 43 1 21        |
| "                      | 30    | 8 7      | 2 1      | 45 3 14        | 40 2 21        |
| "                      | 28    | 8 4      | 2 10     | 43 2 21        | 38 2 14        |
| "                      | 26    | 8 1½     | 2 8      | 38 1 8         | 34 0 12        |
| Cutter                 | 34    | —        | —        | 26 0 0         | —              |
| "                      | 32    | —        | —        | 22 3 14        | —              |
| "                      | 30    | 8 1      | 2 8½     | 17 8 14        | 16 0 7         |
| "                      | 28    | 7 10½    | 2 8      | 15 8 10        | 14 1 14        |
| "                      | 26    | 7 6      | 2 7      | 12 2 6         | 11 1 0         |
| "                      | 25    | 7 2      | 2 6½     | 12 1 0         | 11 0 0         |
| "                      | 23    | 6 11     | 2 5½     | 10 1 21        | 9 2 0          |
| Cutter or Jolly boat   | 18    | 6 0      | 2 2      | 7 2 14         | 7 0 0          |
| Jolly boat             | 16    | 5 7      | 2 2      | 4 3 21         | 4 1 14         |
| Gig                    | 32    | 5 6      | 2 2      | 9 3 14         | —              |
| "                      | 30    | 5 6      | 2 2      | 9 0 7          | 8 2 14         |
| "                      | 28    | 5 6      | 2 2      | 8 0 10         | 7 2 7          |
| "                      | 26    | 5 6      | 2 2      | 7 0 14         | 6 2 14         |
| "                      | 24    | 5 6      | 2 2      | 6 2 21         | 6 0 7          |
| "                      | 22    | 5 6      | 2 2      | 5 2 21         | 5 1 0          |
| "                      | 20    | 5 6      | 2 2      | 5 0 14         | 5 2 14         |
| Cutter gig             | 20    | 6 6      | 2 6      | 7 0 0          | —              |
| Dingy                  | 14    | 5 2      | 2 1      | 4 0 7          | 3 2 7          |
| "                      | 12    | 5 0      | 2 0      | 3 0 7          | 2 3 0          |
| Whale boat             | 27    | 5 2      | 2 6      | 8 2 0          | —              |
| "                      | 25    | 5 2      | 2 4      | 7 2 0          | —              |
| Troop boat             | 36    | —        | —        | 26 2 0         | —              |
| Life boat ('White's'). | 32    | —        | —        | 10 1 19        | —              |
| "                      | 26    | —        | —        | 7 3 11         | —              |

TABLE GIVING THE SCANTLINGS OF SHIPS' BOATS AS BUILT  
IN HER MAJESTY'S NAVY.

[illegible]



## WEIGHT OF MEN AND ANIMALS.

A crowd of people closely packed = 85 lbs. per sup. ft.

The average weight of a man = 140 lbs. 6 ozs., or about 15 men to a ton.

A strong cart-horse = 14 cwt. and a cavalry horse = 11 cwt.

An ox = 7 to 8 cwt. and cow =  $6\frac{1}{2}$  to 8 cwt.

A pig = 1 to  $1\frac{1}{2}$  cwt. and a sheep =  $\frac{3}{4}$  to  $1\frac{1}{4}$  cwt.

## SPACE ALLOTTED TO ANIMALS.

A horse = 120 sup. ft.      A bullock = 40 to 60 sup. ft.

A cow = 90 to 100 sup. ft.      Sheep and pigs = 10 „ 12 „

## VENTILATION, &amp;c.

Each person should be allowed at least from  $2\frac{1}{2}$  to  $4\frac{1}{2}$  cu. ft. of fresh air per minute.

The following are average velocities of air in feet per minute in different positions:—

At outlets where foul air escapes from cabins = 150 to 198.

At inlets where fresh air enters cabins = 78 to 96.

In tubes, trunks, chimneys, &c., for fresh or foul air = 720; or—

$V$  = velocity in feet per minute in chimneys, &c.

$H$  = height of shaft, trunk, &c., in feet.

$T$  = temperature of cabin in degs. Fahr.

$t$  = temperature of external air in degs. Fahr.

$$V = 21.9 \sqrt{H(T-t)}$$

## INCLINATION OF SHIPS' SLIDING WAYS.

For small vessels = 1 in 12 to 1 in 14.

For average „ = 1 „ 16 „ 1 „ 18.

For largest „ = 1 „ 20 „ 1 „ 24.

## TEST LOADS OF ANCHORS AND CHAIN CABLES.

*To find the test load for a given chain cable in tons.*

RULE.—Square the diameter of the bolt of the cable in ins., and multiply the result by 18.

*To find the diameter of a cable in ins. to suit a given test load.*

RULE.—Divide the test load in tons by 18, and subtract the square root of the quotient.

*To find the working load of chain rigging.*

RULE.—Square the diameter of the bolt in ins., and multiply the result by 8.

*To determine the diameter of bolt for a chain cable in ins.*

RULE.—Extract the cube root of the load displacement in tons, and multiply the result by .125.

TABLE GIVING THE NUMBER AND SIZES OF CABLES AND ANCHORS AS SUPPLIED TO SOME OF H.M. ARMOURD STEAM-SHIPS.

| NAME OF SHIP     | Number and Sizes of Cables |            |        |            | Number and Weights of Anchors |            |           |            |              |               |               |               |         |               |   |
|------------------|----------------------------|------------|--------|------------|-------------------------------|------------|-----------|------------|--------------|---------------|---------------|---------------|---------|---------------|---|
|                  | Hempen                     |            |        |            | Iron                          |            | Bower     |            | Stream       |               | Kedge         |               | Stern   |               |   |
|                  | Bower                      |            | Stream |            | Bower                         |            | Stream    |            | No.          |               | Weight of One |               | No.     |               |   |
|                  | No.                        | Cir. cumf. | No.    | Cir. cumf. | No.                           | Dia. meter | No.       | Dia. meter | No.          | Weight of One | No.           | Weight of One | No.     | Weight of One |   |
|                  |                            |            |        |            |                               |            |           |            |              |               |               |               |         |               |   |
| 'Minotaur' class | 10,637                     | 1          | ins.   | ins.       | 3                             | ins.       | 1         | ins.       | 4            | swt. qr. lb.  | 1             | swt. qr. lb.  | 1       | sw. q. lb.    |   |
| 'Warrior' "      | 9,187                      | 1          | 18½    | 18         | 3                             | 2½         | 2         | 1½         | 4            | 112 0 2       | 1             | 14 1 28       | 2       | 45 3 4        |   |
| 'Achilles' "     | 9,894                      | 1          | 19     | 18½        | 6                             | 2½         | 2         | 1½         | 4            | 109 1 52      | 1             | 22 2 16       | 2       | 30 1 4        |   |
| 'Hercules' "     | 8,677                      | 1          | —      | 18         | 5                             | 2½         | 3         | 1½         | 4            | 111 0 0       | 1             | 14 0 0        | 2       | 40 0 0        |   |
| 'Bellierophon' " | 7,651                      | 1          | 19     | 18½        | 5                             | 2½         | 1         | 1½         | 4            | 121 0 14      | 1             | 15 1 14       | 1       | 56 1 0        |   |
| 'Royal Alfred' " | 8,707                      | 1          | 18½    | 14         | 5                             | 2½         | 2         | 1½         | 4            | 90 0 16       | 1             | 11 2 23       | —       | —             |   |
| 'Andromeda' "    | 6,084                      | 1          | 17½    | 14½        | 5                             | 2½         | 2         | 1½         | 4 { 3A 1M 1M | 90 0 7        | 1A            | 30 0 0        | 2A      | —             |   |
| 'Rupert' "       | 6,444                      | 1          | 17     | 13         | 4                             | 2½         | 2 { 1 1 1 | 4M         | 80 1 17      | 1M            | 12 1 17       | 3A            | 8 3 25  | —             | — |
| 'Hotspur' "      | 4,010                      | 1          | 16½    | 13½        | 4                             | 2          | 1         | 1          | 4            | 60 1 16       | 1             | 20 1 23       | 1       | 9 2 0         | — |
| 'Palas' "        | 2,787                      | 1          | 1½     | 12         | 4                             | 2          | 1         | 1          | 4            | 70 2 13       | 1             | 21 3 15       | 3       | 7 0 21        | — |
| 'Scorpion' "     | 2,751                      | —          | —      | —          | 3                             | 1½         | 1         | 1          | 5            | 39 1 0        | 1             | 11 0 0        | 2 { 1 1 | 2 0 0 { 5 0 0 | — |
| 'Research' "     | 1,741                      | —          | —      | —          | 3                             | 1½         | 1         | 1          | 3A           | 47 0 0        | 1A            | 12 0 10       | 2       | 11 1 14       | — |

A = Admiralty.

M = Martin.

TABLE GIVING THE NUMBER AND SIZES OF CABLES AND ANCHORS AS SUPPLIED TO SOME OF H.M. UNARMED STEAM-SHIPS.

| NAME OF SHIP | Displacement in Tons | Number and Sizes of Cables |                 |       |                |       |                | Number and Weights of Anchors |                |       |               |        |               |
|--------------|----------------------|----------------------------|-----------------|-------|----------------|-------|----------------|-------------------------------|----------------|-------|---------------|--------|---------------|
|              |                      | Hawsep                     |                 | Iron  |                | Bower |                | Stream                        |                | Bower |               | Stream |               |
|              |                      | No.                        | Ctr. No. count. | Bower | Dia. No. meter | No.   | Dia. No. meter | No.                           | Dia. No. meter | No.   | Weight of One | No.    | Weight of One |
|              |                      |                            |                 |       |                |       |                |                               |                |       |               |        |               |
| 'Duncan'     | 5,724                | 1                          | 18½             | ins.  | 14½            | 5     | 2½             | ins.                          | 1½             | 4     | 30 0 0        | 1      | 25 0 0        |
| 'Inconstant' | 5,783                | 1                          | 17½             | ins.  | 14½            | 5     | 2½             | ins.                          | 1½             | 4½    | 103 1 0       | 1      | 29 0 0        |
| 'Undaunted'  | 4,020                | 1                          | 18              | ins.  | 13½            | 5     | 2½             | ins.                          | 1½             | 4     | 75 1 0        | 1      | 22 0 0        |
| 'Rover'      | 3,484                | 1                          | 18½             | ins.  | 14½            | 4     | 2              | ins.                          | 1½             | 3A    | 31 8 0        | 1A     | 19 2 14       |
| 'Encounter'  | 1,934                | 1                          | 14½             | ins.  | 11             | 4½    | 1½             | ins.                          | 1½             | 4     | 45 1 15       | 1      | 12 0 21       |
| 'Wild Swan'  | —                    | 1                          | —               | ins.  | —              | 3     | 1½             | ins.                          | —              | 3     | —             | —      | —             |
| 'Nassau'     | 377                  | —                          | —               | ins.  | —              | 3     | 1½             | ins.                          | —              | 3     | —             | —      | —             |
| 'Torch'      | 570                  | —                          | —               | ins.  | —              | 3     | 1½             | ins.                          | —              | 3     | —             | —      | —             |
| 'Ariel'      | 486                  | —                          | —               | ins.  | —              | 3     | 1½             | ins.                          | —              | 3     | —             | —      | —             |
| 'Britomart'  | 330                  | —                          | —               | ins.  | —              | 3     | 1½             | ins.                          | —              | 3     | —             | —      | —             |
| 'Glen'       | 354                  | —                          | —               | ins.  | —              | 3     | 1½             | ins.                          | —              | 3     | —             | —      | —             |

A = Admiralty.

M = Martin.

\* With stock.

## BENDING MOMENTS AND SIZES OF PADDLE AND SPRING BEAMS.

$W$  = load in tons.       $D$  = diameter of shaft in ins.  
 $L$  = length of outboard part of shaft in ins.  
 $L'$  = length of projecting part of paddle beam in ins.  
 $M$  = approximate bending moment of paddle beam.  
 $M'$  = approximate bending moment of spring beam at middle.  
 $E$  = effective sectional area of iron paddle-beam.  
 $B$  = depth of iron paddle-beam in ins.  
 $B'$  = depth of square wood in paddle beam in ins.  
 $s$  = span from centre to centre of paddle beams.

$$W = \frac{D^2 \times L}{4000} \qquad M = W \times L' \qquad M' = \frac{W \times s}{2}$$

$$E = \frac{3M}{4B} \qquad B' = \sqrt[3]{12 \times M}$$

*Note.*—The breadth of the spring beam should not be less than  $\frac{2}{3}$  of the depth of the paddle beams.

## NOMINAL HORSE-POWER.

(*Low-pressure Engines.*)

$V$  = assumed velocity of piston = 128 feet per minute  $\times$  cube root of length of stroke.  
 $V'$  = real velocity of piston in feet per minute.  
 $D$  = diameter of piston in ins.  
 $N$  = nominal horse-power for Admiralty *paddle* engines, and for *paddle* and *screw* engines in the merchant service.  
 $N'$  = nominal horse-power for Admiralty *screw* engines.  
 $P$  = assumed mean effective pressure = 7 lbs. per sq. in.  
 $A$  = area of piston in sq. ins.       $L$  = length of stroke in feet.

$$N = \frac{PVA}{33000} = \frac{A \sqrt[3]{L}}{47} = \frac{D^2 \sqrt[3]{L}}{60} \text{ nearly}$$

$$N' = \frac{PV'A}{33000} = \frac{V'D^2}{6000}$$

*Note.*—To adopt the above formulæ for high-pressure engines the effective pressure is taken at 21 lbs. per sq. in.

## INDICATED HORSE-POWER.

$A$  = area of piston in sq. ins.       $L$  = length of stroke in feet.  
 $P$  = mean effective pressure of steam in cylinder in lbs. per sq. in.  
 $R$  = number of revolutions per minute.  
 $r$  = number of revolutions per second.

$$\text{Indicated horse-power} = \frac{2L \times A \times P \times R}{33000} = \frac{2L \times A \times P \times r}{550}$$

## SCREW-CUTTING.

$L$  = number of teeth in wheel on traverse screw.

$M$  = number of teeth in wheel on mandrel.

$N$  = number of teeth in driven stud-wheel (gearing in  $M$ ).

$P$  = number of teeth in driving stud-pinion (gearing in  $T$ ).

$T$  = number of threads per inch on traverse screw.

$C$  = number of threads to be cut per inch.

$$C = \frac{TL}{M} \text{ single gear 2 wheels.}$$

$$P = \frac{LNT}{MC} \quad N = \frac{MPC}{LT} \quad C = \frac{LNT}{MP} \text{ double gear 4 wheels.}$$

## POSITION OF STATIONS AFLOAT.

FIG. 192.



Let  $S$  be the position of station afloat,  $A$ ,  $B$ , and  $C$  three stationary land-marks. Measure the two angles  $ASB$  and  $BSC$  simultaneously, and set them off on a piece of tracing paper; and shift them on the plan till the three lines traverse the three points  $A$ ,  $B$ , and  $C$ .

TABLE GIVING THE DIMENSIONS OF ARMOUR BOLTS AS USED IN H.M. IRONCLADS.

| Thickness of Armour     | Diameter of Bolt | Diameter of Head of Bolt | Length of Cone  | Number of Threads | Depth of Nut   | Width of Nut across Sides |
|-------------------------|------------------|--------------------------|-----------------|-------------------|----------------|---------------------------|
| Inch.                   | Inch.            | Inch.                    | Inch.           | Per Inch.         | Inch.          | Inch.                     |
| 4                       | $2\frac{3}{8}$   | $3\frac{7}{8}$           | $3\frac{1}{8}$  | $5\frac{1}{2}$    | $2\frac{3}{4}$ | $4\frac{1}{2}$            |
| 6                       | 3                | $4\frac{1}{2}$           | $3\frac{3}{8}$  | 5                 | 3              | $5\frac{1}{8}$            |
| $6\frac{1}{2}$ , 7, & 8 | $3\frac{1}{4}$   | $4\frac{9}{16}$          | $3\frac{5}{8}$  | 5                 | $3\frac{1}{4}$ | $5\frac{1}{4}$            |
| 9                       | $3\frac{3}{8}$   | $4\frac{1}{2}$           | $3\frac{7}{8}$  | 4                 | $3\frac{1}{2}$ | $5\frac{1}{2}$            |
| 10                      | $3\frac{1}{2}$   | $5\frac{1}{4}$           | $4\frac{1}{8}$  | 4                 | $3\frac{3}{4}$ | $6\frac{1}{2}$            |
| 11 & 12                 | 4                | $5\frac{1}{2}$           | $4\frac{1}{4}$  | $3\frac{1}{2}$    | 4              | $6\frac{3}{4}$            |
| 13                      | $4\frac{1}{4}$   | 5                        | $4\frac{3}{8}$  | $3\frac{1}{2}$    | $4\frac{1}{4}$ | $6\frac{1}{2}$            |
| 14                      | $4\frac{3}{8}$   | $6\frac{1}{16}$          | $5\frac{1}{16}$ | 3                 | $4\frac{1}{2}$ | $7\frac{1}{8}$            |

## RELATIVE DURABILITY OF SHIPS' SHEATHING AT SEA.

The following give the relative loss of weight per month on each square foot of surface in lbs. :—

Steel = .0216. Iron = .0204. Zinc = .0070. Copper = .0061.

## RELATIVE CORROSION OF IRON IN SEA WATER.

|                                   |        |
|-----------------------------------|--------|
| Iron by itself . . . . .          | 1.000. |
| „ in contact with brass . . . . . | 8.484. |
| „ „ „ copper . . . . .            | 4.958. |
| „ „ „ lead . . . . .              | 5.550. |
| „ „ „ gun metal . . . . .         | 6.534. |
| „ „ „ tin . . . . .               | 8.657. |

## DIFFERENCE IN DRAUGHT OF WATER WHEN AT SEA AND IN THE RIVER.

W = displacement of ship in tons.

D = displacement per inch in tons at load water-line in sea water.

I = increase of draught of water in river in ins.

$$I = \frac{W}{40 \times D}$$

## SLIP OF SCREW OR PADDLE.

V = velocity of centre of floats or speed of screw in feet per second.

v = velocity or speed of ship in feet per second.

s = slip per cent.

$$s = 100 \frac{V - v}{V}$$

$$v = 100 \frac{V - v}{s}$$

## FREE-BOARD.

*Lloyds' old rule* allows 2 ins. free-board per foot depth of hold of 8 feet; above that,  $\frac{1}{10}$  in. for every extra foot depth of hold.

*Mr. Barnaby's rule* allows one-eighth the beam, with the addition of one-thirty-second part of the beam, for every beam in the length of the ship above five beams.

## SURVEYOR'S RULE FOR APPROXIMATE REGISTER TONNAGE.

(See also '*Register Tonnage*,' pp. 82, 83.)

G = girth in feet. B = breadth in feet. L = length in feet.

R = approximate gross register tonnage.

$$R = \frac{17}{10000} \left( \frac{G \times B}{2} \right)^2 \times L \text{ for wood and composite ships.}$$

$$R = \frac{18}{10000} \left( \frac{G \times B}{2} \right)^2 \times L \text{ for iron ships.}$$

PILE-DRIVING. (*Rankine.*)

- P = greatest load the pile has to bear in tons.  
W = weight of ram in tons.  
H = height of fall of ram in feet.  
L = length of pile in feet.  
D = depth driven by last blow in decimals of a foot.  
A = sectional area of pile in square inches.  
k = constant depending on kind of material.

$$P = \sqrt{\left(\frac{4AWHk}{L} + \frac{4A^2D^2k^2}{L^2}\right) - \frac{2ADk}{L}}$$
$$WH = \frac{P^2L}{4Ak} + PD \qquad D = \frac{WH}{P} - \frac{PL}{4Ak}$$

- k = 400 to 600 for elm.  
k = 500 for alder and sycamore.  
k = 500 to 600 for greenheart.  
k = 600 for beech.  
k = 100 for teak.

| TABLE GIVING THE NUMBER OF WATER-TIGHT COMPARTMENTS IN VARIOUS VESSELS OF THE ROYAL NAVY.<br>( <i>Trans. Inst. of Nav. Arch.</i> , vol. xvii.) |                     |                         |       |              |                     |                         |       |
|--|---------------------|-------------------------|-------|--------------|---------------------|-------------------------|-------|
| NAME OF SHIP   | In Interior of Ship | Double Bottom and Wings | Total | NAME OF SHIP | In Interior of Ship | Double Bottom and Wings | Total |
| Achilles .   | 40                  | 66                      | 106   | Monarch .    | 33                  | 40                      | 73    |
| Alexandra .  | 41                  | 74                      | 115   | Nelson .     | 83                  | 16                      | 99    |
| Devastation .  | 68                  | 36                      | 104   | Resistance . | 47                  | 45                      | 92    |
| Dreadnought  | 61                  | 40                      | 101   | Rupert .     | 40                  | 40                      | 80    |
| Glatton .  | 37                  | 60                      | 97    | Shannon .    | 44                  | 32                      | 76    |
| Gorgon .   | 19                  | 20                      | 39    | Sultan .     | 27                  | 40                      | 67    |
| Hector .   | 41                  | 52                      | 93    | Téméraire .  | 44                  | 40                      | 84    |
| Hercules .   | 21                  | 40                      | 61    | Triumph .    | 26                  | 40                      | 66    |
| Hotspur .  | 26                  | 32                      | 58    | Vanguard .   | 23                  | 40                      | 63    |
| Inflexible .   | 89                  | 46                      | 135   | Warrior .    | 35                  | 57                      | 72    |

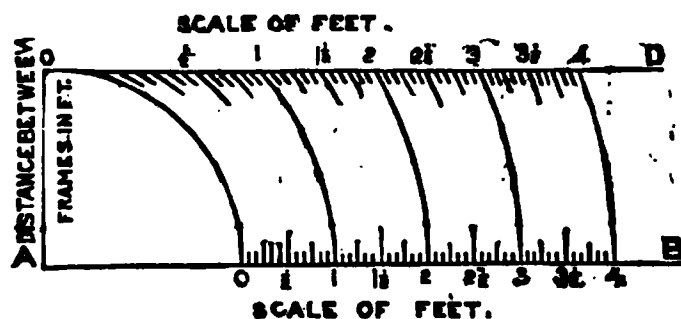
TO CONSTRUCT A SCALE FOR TAKING AN EXPANSION FROM THE BODY PLAN OF A SHIP (fig. 193).

(*C. W. Merrifield, Esq.*)

Set off a base line AB, and at the end set up a perpendicular AO equal to the perpendicular distance between the frames in

feet and inches; then through O draw OD parallel to AB; then from A as centre and OA as radius describe the quadrant OO, cutting AB in O; then from O set off towards B a scale of equal parts in feet and inches, as 0,  $\frac{1}{2}$ , 1,  $1\frac{1}{2}$ , &c.; then with A as centre describe the scale 04 on AB, on to the line OD: if the edge OD of the scale be then applied at the given point on the body plan perpendicular to the lines of the frames, the distance between the two frames at that point measured on the scale will give the *actual* distance between the frames in *space* in feet and inches.

FIG. 193.



cular to the lines of the frames, the distance between the two frames at that point measured on the scale will give the *actual* distance between the frames in *space* in feet and inches.

### COEFFICIENT OF MERIT FOR FULLY RIGGED IRONCLADS.

A = weight of armour in tons per ton of ship's measurement.

G = weight of protected guns and ammunition.

H = height of battery port sills above load water-line in feet.

S = speed in knots at measured mile.

L = length of ship in feet.

$$\text{Coefficient of merit} = \frac{A \times G \times H \times S^2}{L}$$

### COEFFICIENTS OF MERIT OF SOME OF H.M. IRONCLADS.

|             |         |          |          |          |          |
|-------------|---------|----------|----------|----------|----------|
| Achilles    | = 42.9. | Captain  | = 83.3.  | Monarch  | = 149.8. |
| Bellerophon | = 58.6. | Hercules | = 113.4. | Vanguard | = 83.0.  |

### COLOURS FOR WORKING DRAWINGS.

| Material.           | Representative Colour.                       |
|---------------------|--|
| Brass . . .         | gamboge or chrome yellow.                    |
| Brick-work . . .    | crimson lake or carmine.                     |
| Cast iron . . .     | neutral tint or Payne's grey.                |
| Clay or earth . . . | burnt umber.                                 |
| Concrete . . .      | sepia with dark markings.                    |
| Copper . . .        | carmine or lake mixed with burnt sienna.     |
| Granite . . .       | pale Indian ink.                             |
| Lead . . .          | Indian ink tinged with Prussian blue.        |
| Steel . . .         | pale blue tinged with lake or carmine.       |
| Water . . .         | cobalt or verdigris.                         |
| Woods . . .         | burnt sienna, or raw sienna for light woods. |
| Wrought iron . . .  | Prussian blue or indigo.                     |

*Note.*—The usual method is to colour at least all the sectional parts; when both parts are coloured the sectional are coloured much darker than the other parts.



| CIRCULAR SPEED FOR SAWS IN REVOLUTIONS PER MINUTE. |                     |                      |                      |                     |                      |
|--|---------------------|----------------------|----------------------|---------------------|----------------------|
| Diam. of Saw in Ins.                               | Revs. for Thin Saws | Revs. for Thick Saws | Diam. of Saw in Ins. | Revs. for Thin Saws | Revs. for Thick Saws |
| 10   | 2,900               | 3,000                | 25                   | 1,400               | 2,100                |
| 15   | 1,800               | 2,700                | 30                   | 1,200               | 1,800                |
| 20   | 1,500               | 2,400                | 36                   | 1,000               | 1,500                |

THERMOMETERS.

F = Fahrenheit.      R = Réaumur.      C = Centigrade.

$$C = \frac{5(F - 32)}{9} = \frac{5R}{4} \quad R = \frac{4(F - 32)}{9} = \frac{4C}{5} \quad F = \frac{9R}{4} + 32 = \frac{9C}{5} + 32$$

DIAMETERS OF SCREW PROPELLERS.

(See also pp. 480-483.)

|                |       |       |       |       |       |       |       |       |      |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|------|
| I.H.P. . . .   | 8,000 | 7,000 | 6,000 | 5,000 | 4,000 | 3,000 | 2,000 | 1,000 | 100. |
| Diamr. in feet | 24.0  | 23.5  | 23.0  | 22.0  | 21.0  | 19.0  | 15.0  | 10.0  | 6.0. |

| TABLE GIVING THE BREAKING STRAIN OF TILLER ROPES. |                 |      |                 |             |                 |      |                 |
|---|-----------------|------|-----------------|-------------|-----------------|------|-----------------|
| HIDE ROPES  |                 |      |                 | WHITE ROPES |                 |      |                 |
| Cir.  | Breaking Strain | Cir. | Breaking Strain | Cir.        | Breaking Strain | Cir. | Breaking Strain |
| Ins.  | T. Cwt. Qr.     | Ins. | T. Cwt. Qr.     | Ins.        | T. Cwt. Qr.     | Ins. | T. Cwt. Qr.     |
| 2½  | 1 5 2           | 4½   | 4 2 2           | 2½          | 2 6 0           | 4½   | 7 8 2           |
| 3   | 1 16 3          | 5    | 5 2 0           | 3           | 3 6 0           | 5    | 9 3 2           |
| 3½  | 2 10 0          | 5½   | 6 3 2           | 3½          | 4 10 0          | 5½   | 11 2 1          |
| 4   | 3 5 0           | —    | —               | 4           | 5 17 2          | —    | —               |

NUMBER OF SHOT IN PILES.

In a triangular pile =  $\frac{1}{6}\{n(n+1) \cdot (n+2)\}$  = number ; when  $n$  = number in each side of base.

In a square pile =  $\frac{1}{6}\{n(n+1) : (2n+1)\}$  = number ; when  $n$  = number in each side of base.

In a rectangular pile =  $\frac{1}{6}\{3N - (n-1) \cdot (n+1) + n\}$  = number ; when  $N$  = number in longest side of base and  $n$  = number in shortest side of base. :

DIAMETER IRON FOR SHACKLES TO CHAINS.

(Admiralty Rule.)

From ¼ to ½ inch chain, the iron in shackles to be ⅓th of an inch more in diameter than the chain.

Above ½ to ¾ inch chain, the iron in shackles to be ¼ of an inch more in diameter than the chain.

Above ¾ to 1 inch chain, the iron in shackles to be ⅕th of an inch more in diameter than the chain.

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